A
Dictionary
of
Chemistry

A DICTIONARY OF CHEMISTRY.

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I. ABSORBENT. *(a)*
II. ACETOUS. *(b)*
III. ACESCENT.

This word may be employed to denote a matter, which either is turning sour, that is to say, acid, or which is slightly acid. *See* ACID. *(c)*

IV. ACID. Acids are of all saline substances the most simple, and consequently ought to be considered as *secondary principles*. Their name is derived from their taste, which is acid or sour. One of the marks by which they are easily known, is their property of changing into red the blue colors of an infusion of flowers of violets, or of the tincture of heliotropium. *(d)*

If acids were separated from all moisture or water, and from all other substances not necessary to their saline essence, they would appear under a concrete

(a) ABSORBENT. Those *earths* are called *absorbent*, which are capable of being combined with acids. These are calcareous earths, ashes of burnt vegetable and animal substances, magnesia, and earth of alum. This class of earths might be more properly denominated *alkaline earths*. *See* EARTH, MAGNESIA, ALUM.

(b) ACETOUS. *Acetous acid* is the same as vinegar. *Acetous fermentation* is that fermentation by which vinegar is produced. *Acetous ether* is an ether made by means of vinegar. *See* VINEGAR, and ETHER.

(c) The word *acescent* can only be properly applied to denote the first of these meanings. The second may be expressed by either of the words, *acidulous* or *subacid*.

(d) This property of changing the blue, and of heightening the red colors of vegetables, is not common to all acids, for the volatile sulphureous acid destroys these colors: nor is it peculiar to acids; for alum, a neutral salt, produces the same effect.

or ſolid form. But generally they are liquid ; becauſe their affinity to water is ſo great, that when they contain no more than what is neceſſary to conſtitute them ſalts, they are ſtrongly diſpoſed to ſeize more water, whenever they can touch it ; and as the atmoſphere is always loaded with watery vapors, the contact of the air is ſolely ſufficient to render acids fluid, by their rapid union with its moiſture.

Acids have a general tendency to unite with almoſt all ſubſtances, particularly with thoſe which are either ſimple, or not much compounded ; as phlogiſton, alkaline ſalts, fixed and volatile, earths, (eſpecially thoſe called *abſorbent*), metallic ſubſtances, water, and oil.

Many ſubſtances are by chemiſts called *acids*, becauſe they poſſeſs thoſe general properties which we have mentioned. But theſe ſubſtances differ from each other by properties peculiar to each.

As acids from their tendency to unite, and to remain united with almoſt all other bodies, are never found ſingle and pure, but muſt be obtained and ſeparated by artificial operations from the bodies with which they happen to be combined ; they have been diſtinguiſhed by authors into claſſes, according to the ſubſtances whence they are extracted. Theſe claſſes are *mineral acids*, *vegetable acids*, and *animal acids*. In Mr. Geoffroy's Table of Affinities, thoſe of acids are marked in the following order : fixed alkali ; volatile alkali ; earths ; metallic ſubſtances. *(e)*

Very concentrated acids taken internally in a doſe ſomewhat large ; for inſtance, an ounce, or even much leſs, when the acid is ſuſceptible of great concentration ; are corroſive and genuine poiſons. Their beſt antidotes are alkaline ſubſtances, either ſaline or earthy, oils, alkaline ſoaps, large quantities of mild drink, as water, milk, mucilages. Theſe muſt be given copiouſly and ſpeedily.

Small doſes of acids diluted with much water, ſo as to be agreeably acidulous, and blunted by ſome mild ſubſtance, as ſugar, are excellent cooling and aperitive medicines, fit to quench exceſſive thirſt, and leſſen the acrimony of the bile. They are chiefly uſeful in alkaleſcent diſpoſitions, and in putrid, inflammatory fevers. Their whole action ſeems to be exerted on the primæ viæ ; for they are rendered unactive by the powers of digeſtion, by means of which they are combined with the earthy and oily parts of aliments and digeſtive juices. They would be certain poiſons if they paſſed into the blood veſſels with their acid qualities, at leaſt with their acidity undiminiſhed. They would coagulate the blood, and would greatly irritate the nervous and ſenſible parts. Malpighi killed a dog by injecting into the veins ſuch a quantity of nitrous acid, as would not have hurt, if it had been ſwallowed. Acids employed externally ſhew ſimilar qualities, but more ſenſibly than when impaired by the digeſtive powers. They are uſeful againſt alkaleſcent putridity. *(f)*

(e) The *affinities or powers of union of acids* are, 1. Fixed alkali ; 2. Calcareous earth ; 3. Volatile alkali, and magneſia, the powers of union of theſe two being nearly equal ; 4. Iron, zinc, copper, and perhaps ſome other metals ; 5. Earth of alum ; 6. The remaining metals.

(f) I. The *common properties of acids* are, 1. They may be united with water. This is not merely a dilution of acids, for by uniting them with a certain quantity of water, heat or cold is produced ; and the mixed fluid acquires a ſpecific gravity, different from the

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V. ACIDS (ANIMAL). This name is given to acids obtained from certain animal matters; as butter, fat, blood, ants, and most flies.

These acids have been too little examined to enable us to judge whether they be essentially different from those obtained from vegetables. But we are certain, that they differ in the same circumstances as the vegetable acids do from mineral acids; and probably, this difference proceeds from the same cause

intermediate gravity of its component parts. From this union, therefore, a new compound is formed. 2. They may be combined with spirit of wine. *See* ETHER. 3. They may be combined with absorbent earths. 4. They may be combined with alkaline salts. 5. They may be combined with metallic substances. Although every acid does not directly dissolve every metallic substance, yet probably by concentration or dilution of the acid, division of the metals by mechanical and chemical methods, by application of sufficient heat, and other means, every metal may be acted upon by every acid. 6. They may be combined with phlogiston, and with oils. 7. When they combine with these substances, they disengage from them all or part of the fixable air which they contain. 8. They soften and dissolve the solid parts of animals. 9. They coagulate most of the liquid parts of animals. 10. They change to red the blue, and heighten the red colors of vegetables, excepting volatile, sulphureous acid, which destroys these colors. Probably this change of color proceeds from the action of acids upon the oily parts of vegetables; for oils are rendered red by sufficiently concentrated acids. 11. They resist fermentations. 12. They are not capable of being frozen by so small a degree of cold as water is. 13. They produce cold when poured upon ice.

2. As acids so powerfully attract water, that they are never found pure and dry, but always in a fluid state, when uncombined with earths, alkalies, or metals, we cannot easily ascertain the quantity of acid contained in acid liquors. Homberg has attempted to estimate the quantity of acid contained in the acid spirits of vinegar, nitre, sea-salt, and of vitriol, by combining these liquors with salt of tartar, so as to form neutral salts; imagining that the weight gained by that alkali from its union with acids, or the difference betwixt the weight of the salt of tartar and the neutral salt produced, was equal to the weight of real acid contained in the quantity of acid liquor employed. But as he did not consider, that the air expelled from salt of tartar, during its combination with acids, makes a very considerable part of the weight of that alkali, the inferences from his experiments are not just; and the real quantity of acid contained in an acid liquor, is so much more than the quantity inferred by him, as the whole weight of the fixable air disengaged from the salt of tartar. The quantity of fixable air contained in salt of tartar varies much according to the method of its preparation, and other circumstances; but if we suppose that the fixable air in the salt of tartar, used by Homberg, was in as great a proportion as in the pearl-ashes of Mr. Cavendish, [Phil Transf. 1766] that is $\frac{284}{1000}$ of the whole weight of the alkali, by adding $\frac{284}{1000}$ of the alkali used in each experiment, we shall nearly find the true quantity of solid acid in each neutral salt. The first column shews the quantity of each of the acids employed to saturate an ounce of salt of tartar; and the second column shews the quantities of the neutral salts produced.

1.	2.
Distilled vinegar, 14 oz.	oz. 1. dr. 3. gr. 36.
Spirit of salt, oz. 2. dr. 5.	oz. 1. dr. 3. gr. 14.
Spirit of nitre, oz. 1. dr. 2. gr. 36.	oz. 1. dr. 3. gr. 10.
Acid of vitriol, dr. 5.	oz. 1. dr. 3. gr. 5.

Homberg supposes, that in each of the neutral salts, the quantities of which are mentioned in the second column, the quantity of contained alkaline salt is equal to an ounce, and the quantity of contained acid is equal to the remaining weight; whereas by

which conſtitutes the difference betwixt the vegetable and mineral acids; namely, the combination of oily particles with the former. (*g*)

The *phoſphoric acid*, obtained from urine, appears, for the ſame reaſon, to belong to this claſs of animal acids. But it has properties ſo different from thoſe

by our propoſed method of correction, ſuppoſing ſtill that the quantity of fixable air in his ſalt of tartar was $\frac{284}{1000}$ of the whole weight, we ſhall find that of the oz. 1. dr. 3. gr. 5. of vitriolated tartar in the laſt mentioned inſtance of the table, dr. 5. gr. 44. were fixed alkali deprived of its air, and dr. 5. gr. 21. were acid. Hence we may perceive that the quantities of alkali and of acid in the ſeveral neutral ſalts, the weights of which are expreſſed in the ſecond column of the table, are very nearly equal. *See* AIR (FIXABLE.)

3. The *known acids* are, 1. Vitriolic acid. 2. Nitrous acid. 3. Marine acid. 4. Acetous acid. 5. Vinous acid, or tartar. 6. Eſſential acid of vegetables. 7. Acid obtained by diſtillation of vegetables. 8. Acid of bitumens. 9. Acid of borax. 10. Acid obtained by diſtillation of oils, reſins, and fats. 11. Phoſphoric acid. 12. Acid of ants and other inſects. 13. Acids of healthy and of diſeaſed ſtomachs of animals. 14. Acid of perſpirable matter of diſeaſed animals. Perhaps the number of acids is much larger; or perhaps ſome of theſe are only modifications of other primary acids; or laſtly, as Stahl ſuppoſes, they are all modifications of the one only primary acid, namely, that of vitriol. *See the theory of acids under the article* SALT.

(*g*) The acid of ants may be perceived by ſmell, on turning up an ant-hill in ſpring or ſummer. When theſe inſects are irritated, they diſcharge a fluid which has an acid taſte and ſmell. Water, or ſpirit of wine, in which they are agitated, becomes acidulous. Part of this acid is ſo volatile as to riſe by diſtillation with ſpirit of wine, in which ants had been immerſed; but the greateſt part of it is ſo fixed, as to remain united with the reſiduous phlegm. All the acid may be extracted by water, and rendered capable of riſing by diſtillation with that fluid in a water-bath. From 24 ounces of freſh ants were obtained by diſtillation, without addition, eleven ounces and two drams of acid ſpirit, ſome urinous ſalt and ſpirit, ſome empyreumatic oil, and a reſiduum, conſiſting of earth and fixed ſalt. This acid is found to have the general properties of acids. With fixed alkalies it forms neutral cryſtals, oblong, and deliqueſcent. Theſe cryſtals being diſtilled by a violent fire, yielded a liquor ſcarcely acid, and another liquor urinous or ammoniacal. From the reſiduum diſſolved in water, by filtration and evaporation, were obtained large cryſtals which did not deliquiate, and had the general properties of fixed alkalies. In this experiment the acid ſeemed to diſappear. But by pouring oil of vitriol on theſe alkaline cryſtals, white vapors were diſengaged, although no acid ſpirit could be obtained by diſtillation. From theſe white vapors, and from the facility with which this ſalt cryſtalizes, Mr. Margraaf, from whom theſe and the following experiments on the acid of ants are extracted, ſuſpects the exiſtence of a latent acid. The acid of ants formed with volatile alkali an ammoniacal fluid, which, like the combination of the ſame alkali with vinegar, could not be reduced to a concrete or ſolid ſtate. With quicklime, chalk, and coral, it formed dry cryſtals.

This acid did not precipitate ſilver, lead, or mercury, from nitrous acid; hence it has no analogy to marine acid. Nor did it precipitate quicklime from marine acid; and hence it has no analogy to vitriolic acid.

As a menſtruum, this acid acted weakly upon copper, and ſtrongly upon iron and upon zinc; but it did not act, or very little, upon ſilver, lead, tin, regulus of antimony and biſmuth. Its combination with iron cryſtallized; in which reſpect it differs from vinegar. It diſſolved the calxes of copper, ſilver, zinc, and lead; but not the calxes of tin, regulus of antimony, biſmuth, or of mercury, which laſt calx it converted to fluid quickſilver. Upon the whole (ſays Margraaf), we may perceive a reſemblance in many reſpects, though not in all, betwixt this acid and the acetous. *See the Memoirs of*

of all other acids, that it deserves to be considered as a distinct acid. *See* PHOSPHORUS.

VI. ACIDS (CONCRETE). These are saline, solid substances which have the general properties of acids. Such are, *crystals of tartar*; *essential salts of vegetables*, particularly of those which are acid; the *volatile acid salt of amber*, and of some other *bitumens*; and *flowers of Benjamin*.

VII. ACID *of* VINEGAR. *See* VINEGAR.

VIII. ACIDS (FLUOR), Are those which are generally, or always in a fluid state; such are the volatile vitriolic, nitrous, marine acids, and those obtained by distillation from vegetable and animal substances.

IX. ACID (MARINE). This is so called, because it is generally obtained from sea-salt; though it may be also procured from *Sal-gem*, or *fossile salt*, and from the salt of saline fountains and pits, since all these salts are different from sea-salt, only as to their origin.

The marine acid, as well as the nitrous and vitriolic, is never found alone and pure; but it is always combined with an alkali, so as to form a neutral salt, which is dissolved copiously in the sea, to which it gives a salt taste.

This neutral salt is also found crystallized in large transparent masses within the earth, and is then called *Sal-gem*, or *fossile salt*.

It is also dissolved in the waters of some *wells* or *fountains*, which may be owing to these waters communicating by subterraneous passages with the sea, or to their passing through mines of *Sal-gem*.

The marine acid has all the general properties of saline acid substances.

It differs from the vitriolic acid in the following circumstances: it is more light and volatile; it has smell and color; it emits vapors; it has less affinity with fixed alkalies and absorbent earths; and, like the nitrous acid, it forms with absorbent earths no salts but such as are deliquescent.

It differs from the nitrous acid by its color, which is more yellow and less red; by the whiteness of its vapors, which are visible only in open air; by its smell, which resembles saffron; by a weaker affinity with absorbent earths and fixed alkalies. (*b*)

The marine acid cannot be so much concentrated as the vitriolic and nitrous acids, because it is more volatile.

This acid cannot be so easily combined with phlogiston as the vitriolic and nitrous, and we are not certain that some medium is not requisite for such a combination.

Although the properties of the marine acid are as well known as those of nitrous and vitriolic, yet chemists are far from understanding the nature of this saline substance equally well. Becker, according to his theory of acids, attributes the distinguishing properties of the marine acid to that principle which

the Berlin Academy, vol. 4. 1749, or the *Opuscules Chemiques de Mr. Margraaf*.

Insects armed with stings, as bees, wasps, and hornets, when irritated, discharge an acid liquor.

(*b*) Marine acid differs from the nitrous in another instance, besides those mentioned in the text. It readily dissolves metallic calxes, which are little affected by nitrous acid. Hence it extracts from most colored earths and stones the metallic calxes, by which the color of these substances is produced.

he calls *mercurial earth*. But he supports his opinion by no other proofs, than by some appearances caused by the union of this acid with metallic substances, in which also he supposes this mercurial earth to be a component part. But as the existence of this mercurial earth in marine acid, or in metallic substances, is not demonstrated, nor even sufficiently indicated; and as Becker has explained himself very obscurely and confusedly on this subject, what he has said does not merit a deliberate discussion. Stahl, therefore, who was too judicious to be satisfied with appearances and probabilities, abandoned, in some measure, this part of Becker's theory, and only expresses a wish that the existence of the mercurial earth could be as well ascertained as the existence of phlogiston.

This great chemist, however, appears to be convinced of the primary identity of all saline substances; that is to say, he believed that they all were the vitriolic acid disguised by some mixture. He assures us, even, that he has been able to transmute acids into each other; that is, to change the vitriolic acid into the nitrous and marine; and to reduce these back again into the vitriolic. But he has not published his experiments on this subject, perhaps because he had not sufficiently ascertained the processes, or that he chose to reserve to himself such important discoveries. The possibility, therefore, of these transmutations of acids is not yet determined. *(i)*

The properties of the marine acid, above-mentioned, indicate nothing more than that it participates of the nature of both the vitriolic and nitrous acids.

Its combination with phlogiston, which, of all its properties, might assist us most in our investigation, has not been sufficiently explained.

The unsuccessful attempts made by M. Margraaf, a celebrated chemist of the academy of Berlin, to combine the marine acid pure and crude, as he calls it, with phlogiston, with a view to compose phosphorus, are so many fresh causes of uncertainty, and additional motives to endeavor the illustration of this important object. *See* PHOSPHORUS.

Marine acid, combined to the point of saturation with marine alkali, called also mineral or fossil alkali, forms a neutral salt, crystalizing in cubes, of an agreeable, salt taste. *See* COMMON SALT under the article SALT.

With volatile alkali it forms a neutral, crystalized, and very pungent salt. This salt is semi-volatile, and may be sublimed with a certain degree of heat. It is called *Sal ammoniac*. *See* AMMONIAC.

Metallic substances are in general more difficultly dissolved by the marine than by the vitriolic and nitrous acids, because the first has less affinity than the other two with phlogiston, which is the medium of union betwixt metals and acids.

Marine acid, when fluid, however much concentrated, and assisted by any heat, cannot dissolve gold, silver, platina, or mercury, in their natural or metallic state. It combines however very well and intimately with silver and mercury by two methods. One of these is called the dry method or cementation, because the acid then, in some measure, is dry, and exposed to the greatest heat it is capable of receiving. *See* PARTING (CONCENTRATED) and SUBLIMATE

(*i*) Concerning the identity of acids, see the article SALT. Concerning the transmutation of marine acid into the acid of nitre, *see* also ACID (NITROUS).

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(CORROSIVE). The second method is called the *humid way*, and consists in separating these metals fro... ...eir solutions in nitrous acid. See LUNA CORNEA, and PRECIPITATE (WHITE).

This acid, when pure and unmixed, cannot by any known method dissolve gold or platina. But when it is mixed with the nitrous acid, it forms a menstruum called *aqua regia*, which readily dissolves these metals. See AQUA REGIA. From combinations of aqua regia with gold or platina, metallic salts are formed susceptible of crystalization. See GOLD, and PLATINA. (k)

Pure marine acid dissolves sufficiently well tin, lead, copper, iron, zinc, and bismuth; and less easily regulus of antimony: and it forms with these metals different salts, the properties of which see under the articles TIN, LEAD, &c. (l).

The general phenomena, most remarkable in the combination of marine acid with metallic matters, are;

1. It dissolves these substances with less heat and effervescence, and with fewer vapors, than nitrous acid does. This observation is true, even with respect to those metals which it dissolves most readily, as copper and iron.

2. It forms with all the metals which it dissolves, excepting iron and copper, salts capable of crystalization. The cause of this property is, that generally it takes from metals much less of their phlogiston than the nitrous acid does.

3. The metals with which it contracts the strongest union, as silver, lead, mercury, and the regulus of antimony, are actually those with which it unites most difficultly. We must here observe, that marine acid separates silver, lead, and mercury, from the nitrous acid in which they had been previously dissolved; and when it is once united with these metals, they adhere more strongly to it, than they did to the nitrous acid. This has given occasion to Becker and other chemists to advance, that in marine acid, and in the last mentioned metals, there is more of that principle which they call *mercurial earth*, than in any other acids or metals. And to this abundance of mercurial earth, they attribute the stronger connection of marine acid, and the mentioned metals, which are distinguished from all others by the appellations *white*, *lunar*, and *mercurial*.

4. Marine acid has the property of volatilising, or carrying off with it in sublimation or distillation, entirely or partly, the metals with which it is united, those particularly with which it forms the strongest union, as mercury, regulus of antimony, silver, and lead. See SUBLIMATE (CORROSIVE), LUNA CORNEA, BUTTER of ANTIMONY, and PLUMBUM CORNEUM.

5. Marine acid, though in some respects less strong than the vitriolic or nitrous, forms with metallic substances, and particularly with the last mentioned metals, with which it adheres most firmly, *metallic salts*, much more corrosive than those formed by the other two acids. See CAUSTICITY.

(k) By two methods gold and platina may be rendered soluble in marine acid: 1. by previous solution in aqua regia, and precipitation from that menstruum by means of an alkali; or, 2. by a previous calcination with tin or bismuth.

(l) Marine acid, when boiling, dissolves arsenic. Regulus of cobalt, and the semimetal called nickel, are also soluble in marine acid: the solution of the former is reddish yellow, which is changed to green by application of heat; and the solution of the latter is of a deep green color.

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The greatest part of these phenomena, peculiar to marine acid, evidently proceeds from the difficulty with which it unites with phlogiston, and to the smallness of the quantity of that principle which it takes from metallic substances.

However, these phenomena, thus collected, may, by being compared together, furnish matter for curious speculations concerning the famous mercurial earth of Becker, which, according to him, is the third principle of metallic substances. Besides, in most solutions of metals by marine acid, a singular smell, resembling the smell of garlic, or of arsenic, is exhaled: but, according to Becker, arsenic contains abundantly the mercurial principle.

The difficulty with which marine acid combines with the inflammable principle, is the reason why this acid acts so little upon oils and oily substances. It seems to have no power over these substances when it is fluid and united with a certain quantity of water. What it would produce, if it were artfully applied to these oleaginous matters in its highest degree of concentration, with the help of considerable heat, is not known. Very interesting researches remain yet to be made upon this subject.

It appears that the inflammable principle, when intimately united with water, as in ardent spirits, is in the favorable state for combination with marine acid; although many more difficulties are found in making this combination with the marine acid, than with the vitriolic or nitrous.

Marine acid, mixed with spirit of wine in all proportions, and even frequently distilled with it, is much less intimately combined than the other two acids, and proportionably loses less of its acidity than they do. *See* SPIRIT of SALT (DULCIFIED).

Lately, however, marine acid has been applied to spirit of wine in such a manner, that from their union results a liquor which has the distinguishing properties of ether, and is a true *marine ether*. *M. Baumé*, an able artist, and excellent observer, was the first who published that he had succeeded in making this combination. His method was by applying the vapors of highly concentrated marine acid to the vapors of spirit of wine, by means of a convenient apparatus of vessels. The detail of this fine experiment may be seen in his *Dissertation on Ether*.

Since his time, an illustrious and learned lover of chemistry * has found a method of making marine ether with infinitely more facility, and more abundantly, by distilling along with spirit of wine the *smoaking spirit of Libavius*, which is nothing more than highly concentrated marine acid, charged with a considerable quantity of tin, which it had carried up with it in distillation. *See* SPIRIT (SMOAKING) of LIBAVIUS.

M. Pott, in his dissertation de *acido salis vinoso*, and other chemists, mention the mixture of some metallic salts, containing concentrated marine acid, such as butter of antimony, with spirit of wine. The phenomena which accompanied these mixtures, shewed that these substances re-acted considerably on each other, and consequently were intimately combined.

* The Marquis de Courtanvaux.

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These phenomena, and particularly the easy production of marine ether, by the smoaking spirit of Libavius, prove that the marine acid which has been combined with metallic substances, is in the fittest state for its intimate combination with spirit of wine, and for the formation of an ether. Does it acquire this property, by depositing along with the metals a portion of some of its principles; for instance, of its mercurial earth; or by carrying off some of the principles of the metals? To me the latter seems certainly the method; and that the metallic principle which it carries off is the phlogiston of the metals. The best means of deciding this interesting question, is to combine the acid with several metallic substances, particularly with those which contain much phlogiston and easily part with it, as zinc, regulus of antimony, tin, and iron, and then to separate the acid from these substances; not only to try whether ether can be made by the acid thus prepared, but also to ascertain by the other means which chemistry affords, whether the acid be really by this method combined with a portion of the phlogiston of the metals. Mr. Pott, as well as Stahl, affirms a fact which confirms these notions, and which well deserves to be ascertained; which is, that the properties of the nitrous acid may be given to the marine by combining the latter with iron. But it is very certain, that the principal difference betwixt these two acids, proceeds from the quantity of phlogiston which enters as a principle into the composition of the nitrous. *See* ETHER (MARINE).

The affinities of marine acid, according to Mr. Geoffroy's table, are in the following order: tin, regulus of antimony, copper, silver, mercury. According to Mr. Gellert, its affinities are placed thus: phlogiston, zinc, iron, copper, tin, lead, bismuth, regulus of antimony, mercury, arsenic. This table shews also that it does not dissolve gold, and partly dissolves silver by the dry method. (*m*)

(*m*) The affinity of tin is greater than that of copper to marine acid, according to Mr. Geoffroy's table, and less, according to Mr. Gellert's table. I have observed that tin readily precipitates copper from this acid, and also from aqua regia: Mr. Gellert is therefore mistaken. The affinities of this, and also of other acids to metals, vary in different circumstances. Thus, for instance, although marine acid unites generally with copper or with iron, preferably to mercury, or regulus of antimony; yet if either of these latter metallic substances be added to a mixture of sea-salt and vitriol, green or blue, and considerable heat applied, the marine acid of the sea-salt, disengaged from its basis by the acid of the vitriol, will not unite with the iron or copper of the vitriol, but with the mercury or regulus of antimony, and along with them will be raised by the force of the fire, forming mercury sublimate, or butter of antimony.

Mr. Hellot found, that by repeatedly drying and distilling the mother water of sea-salt, more and more marine acid could be obtained without addition.

Marine acid renders calcareous earths and metals soluble in spirit of wine; but not volatile alkali, as nitrous acid does; nor fixed alkali, as acetous acid does.

Marine acid, together with burning phlogiston, gives a reddish yellow flame. The marine acid of mercury corrosive sublimate, combined with copper, forms a fusible mass, which kindles like sulphur, and burns with a blue flame. The phosphorus of Homberg, which is a combination of the marine acid of sal ammoniac with calcareous earth, to which a portion of the inflammable principle of the sal ammoniac adheres, is luminous

X. ACIDS (MINERAL). Mineral acids are those which are obtained from minerals, or substances dug from the earth; such as *sulphur*, *bitumens*, *alum*, *selenites*, *vitriols*, *clays*, all which contain *vitriolic acid*; the *nitrous earths*, from which nitrous acid is obtained; and *Sal-gem*, sea-salt, or *common salt*, which furnish marine acid.

There are then three mineral acids, the vitriolic, nitrous, and marine. These acids are generally more simple, less volatile, more susceptible of concentration, and stronger than the acids obtained from animals or vegetables. Hence their power of decomposing all the neutral salts whose acids are of the latter kind, of disengaging these acids, and of substituting themselves in their place by uniting with the substance, which together with the animal or vegetable acid had formed the neutral salt. *See* ACID, ACID (VITRIOLIC), ACID (NITROUS), ACID (MARINE).

XI. ACID (NITROUS). Nitrous acid has all the general properties of saline acid substances, mentioned under the article Vitriolic Acid. *See* ACID (VITRIOLIC). But it differs from vitriolic acid in the following circumstances:

1. It is lighter than the vitriolic. The weight of the most concentrated nitrous acid, which can be obtained by ordinary means, is to the weight of water as 19 to 12. See a memoir of Mr. Rouelle concerning the inflammation of oils, in the Memoirs of the Academy for the year 1747.

2. It is of a yellowish-red flame color.

3. It is less fixed than vitriolic acid, and cannot therefore be ever obtained in a concrete form, when unmixed.

4. It perpetually exhales in vapors of the same color as itself.

5. Its smell and taste are peculiar and distinguishing.

6. When highly concentrated, it strongly attracts the moisture of the air, but less strongly than vitriolic acid highly concentrated.

7. When concentrated nitrous acid is mixed with water, a considerable heat and ebullition are produced from the activity with which these two substances combine. While they are mixing, a singular and curious phenomenon appears, which is, that the liquor assumes a blue or deep green color, while the vapors continue still of their original yellowish red. M. Beaumé has made this observation.

This blue color, as the same chemist has remarked, disappears in a few days, if the nitrous acid has been diluted with much water.

Concentrated nitrous acid is very corrosive. It tinges the skin with a yellow color, which does not disappear till the epidermis comes off. It is successfully employed to corrode and gradually destroy warts, and uninflamed, indolent tumors.

nous when struck in the dark. From these facts, together with the preparation of marine ether, we may perceive that marine acid is capable of uniting with phlogiston, and that a marine sulphur might probably be formed, if the volatility of marine acid did not prevent the application of heat sufficient for the forming of that combination.

Homberg found, that marine acid corrodes glass more than any other acid. For the process of obtaining marine acid, see SPIRIT of SALT.

If the opinion of Becker, Stahl, Junker, and all the scholars of Stahl be true, that there is only one primitive acid, whence the rest are formed; and that this most simple acid, the principle of all others, is the vitriolic, then it follows that nitrous acid is nothing else than vitriolic acid, changed by the union of some other principle. Further, these chemists think that nitrous acid is formed from the vitriolic combined, by means of the putrid fermentation, with a certain quantity of phlogiston. To prove their opinion, they give the following reasons:

1. That the nitrous acid is obtained from nothing else than materials impregnated with putrid juices of animal and vegetable substances, which are known to abound with phlogiston: whereas vitriolic acid exists, not only in most minerals, and in the very earths and stones, which are fittest to form a matrix for the generation of nitrous acid, but also in the atmosphere, as appears from the experiment of exposing to the air linnen soaked in a lixivium of alkaline salt, which in a certain time is found to be changed into vitriolated tartar.

2. There is a great analogy betwixt those properties of the nitrous and volatile vitriolic acids, by which each of these acids differs from vitriolic acid, and volatile vitriolic acid is evidently vitriolic acid changed by union with phlogiston.

This volatile vitriolic acid differs from vitriolic acid by its volatility, by its smell, by its weaker adhesion to alkaline salts, by the greater solubility and different form of the crystals resulting from its union with alkaline salts.

But these properties are the same which distinguish nitrous acid from the vitriolic. Besides, the volatile vitriolic and nitrous acids resemble each other, and differ from vitriolic acid in the following respects: 1. They produce a much greater alteration on the colors of vegetables than the vitriolic does: and 2. The salts formed by their combination with fixed alkali resemble each other, and are equally different from vitriolated tartar.

Several new interesting experiments might be made to determine more particularly the analogy betwixt the volatile vitriolic and nitrous acids. The salt resulting from the combination of volatile vitriolic acid and absorbent earths might be examined, in order to discover whether it be deliquescent, like the salt from the combination of the same earth with nitrous acid, and in what other circumstances these two salts resemble each other, and differ from the vitriolic salt with earthy base, or selenites. This inquiry would be still more interesting, as the nitrous salts with earthy bases have also been little examined. *See* SALTS (NITROUS) *with* EARTHY BASES.

Nitrous acid is one of the most powerful menstruums in chemistry: not that it is the strongest acid; for in strength it is inferior to vitriolic acid, and even in certain circumstances to marine acid: but on account of the facility, of the quickness, and of the activity with which it dissolves most substances.

The bodies upon which it acts most forcibly are, phlogiston, alkalies fixed and volatile, metallic substances and earths, particularly of the calcareous and absorbent kinds.

Nothing can equal the impetuosity with which nitrous acid joins itself to phlogiston. It is so great, that probably nitrous acid has a stronger affinity with phlogiston than the vitriolic has: and it is probable too, that

tin, which the nitrous acid deprives of its phlogiston, and in some sort calcines rather than dissolves. *See* TIN. (*o*).

XII. ACID (PHOSPHORIC). *See* PHOSPHORUS.

XIII. ACID (VOLATILE SULPHUREOUS, or VOLATILE VITRIOLIC). This is nothing else than vitriolic acid diluted with water, and weakly united to the inflammable principle. The properties of this acid are then the same *essentially* as those of vitriolic acid. *See* ACID (VITRIOLIC). But the phlogiston which is united with the volatile acid makes it differ considerably from the pure vitriolic acid.

It differs from vitriolic acid, 1. By its smell, which is so active and penetrating, that it can instantaneously suffocate and kill animals. This smell is the same as that of lighted sulphur. As vitriolic acid, when pure and free from phlogiston, has no smell, it appears that the smell of volatile vitriolic acid is caused by its phlogiston; and this is one of the best proofs of the opinion of Stahl and other chemists, who think that phlogiston is the principle of all odors. This opinion will appear even demonstrated, when we consider that no odoriferous substance can be found, in which it is not easy to shew the presence of phlogiston. *See* PHLOGISTON.

2. The volatile acid differs from the vitriolic by its volatility. The latter is the most fixed of the mineral acids, and is for that reason the most susceptible of concentration: but the volatility of the former is so great, that it cannot be much concentrated. This property proves that phlogiston is a principle essentially volatile.

3. The volatile acid is infinitely weaker than vitriolic acid; not only because it cannot be so much concentrated, but also because by its combination with phlogiston it is rendered less simple, and consequently less capable of affinity with other bodies. Therefore, the neutral salts formed by it with alkalies, are easily decomposed by vitriolic acid, and also by all other acids, even the weakest amongst the vegetable.

4. The neutral salt which results from the union of volatile vitriolic acid and fixed alkali, differs much from vitriolated tartar with respect to the figure of its crystals, which are long and needle-like, arranging themselves together in form of tufts or shrubs. Its taste also is different from that of vitriolated tartar, and it is more soluble in water: all these properties shew in a

(*o*) Nitrous acid forms with copper, a green, with iron, a reddish; with lead, a yellow; and with silver, bismuth, mercury, and zinc, colorless solutions. Tin it dissolves imperfectly, and it corrodes regulus of antimony to a white powder. With regulus of cobalt it forms a red, and with nickel a green solution. It dissolves arsenic, and, according to Henckel and Neumann, forms with it a gum-like substance. Dr. Brandt found that by particular management it can dissolve gold: *See* GOLD. It has little effect on metallic calxes.

Nitrous acid combined with chalk forms the phosphorus of Baldwin. *See* PHOSPHORIC STONES. Cohobated and distilled with quicklime, it emitted an inflammable vapor. *See Mr. Pot's Dissertation on the Solution of Quicklime by Nitrous Acid.* With ice this acid produces cold remarkably. Concerning the origin of nitrous acid, *see* NITRE *and* SALT; and for the process of obtaining it, *see* SPIRIT *of* NITRE.

neutral

neutral salt the weak union of its acid and base. This salt is called the *sulphureous salt of* STAHL. *See* SALT (SULPHUREOUS).

5. The action of volatile vitriolic acid is much more evident than of vitriolic acid upon the colors of vegetables, as appears by pouring an equal quantity of each of the two acids into the tincture of violets, or of heliotrope, of cochenille, Brasil wood, &c. In all these instances, the tinctures into which volatile vitriolic acid has been poured, will have lost much more of the intensity of their colors than the other tinctures; that is to say, their colors will be more changed, enlivened, and heightened. This effect is produced to such a degree by this acid, that it destroys most colors, and makes them disappear entirely in time. This property renders it very useful in several arts, by giving to certain matters, for instance to wools and silks, a degree of whiteness to which they could not be otherwise brought. For this purpose, these matters are exposed in a close place to the fumes of burning sulphur, from which, as we shall afterwards see, much of this acid exhales. *See* SULPHUR.

Although volatile vitriolic acid differs essentially from nitrous acid, since the former is nothing else than vitriolic acid disguised by the addition of phlogiston, which is but weakly united to it; nevertheless, it is necessary to remark, that all the properties now recited of the volatile acid, make it resemble nitrous acid as much as they distinguish it from vitriolic acid. From this remark may be drawn one of the strongest presumptions in favor of Stahl's opinion concerning the nature of nitrous acid. This great chemist thinks, that vitriolic acid, which he therefore calls the *universal acid*, is the principle of all other acids, and the most simple of all. He thinks that nitrous acid is particularly nothing else than vitriolic acid combined by means of putrefaction with a certain quantity of phlogiston; but in a manner very different, and infinitely more intimately than the phlogiston is combined in volatile vitriolic acid. For this latter combination is so weak, that it is decomposed by contact of air; so that the most strong and penetrating volatile vitriolic acid, by exposure in open vessels, loses in a little time all its smell and volatility, and becomes entirely similar to a pure and weak vitriolic acid. The same phenomenon takes place when the volatile acid is combined with an alkali. Hence the sulphureous salt of Stahl, exposed for a while to free air, loses all the properties which distinguish it from vitriolated tartar, and becomes no wise different from it.

The true reason of the weakness of adhesion of the phlogiston in volatile vitriolic acid, is the presence of the aqueous principle, above the quantity of water essential to vitriolic acid. This principle always resists a strong and intimate union of phlogiston with any body.

This is so true, that if vitriolic acid deprived of all water except what is essential to it, be applied to any matter containing phlogiston, volatile vitriolic acid is not then produced, but true sulphur, in which the phlogiston adheres more strongly. *See* SULPHUR. On the contrary, when a vitriolic acid, overcharged with superfluous water, is combined with a matter containing phlogiston, volatile vitriolic acid is constantly produced, and never sulphur, except that in the very act of combination the vitriolic acid be deprived of all its super-abundant water.

The great facility which vitriolic acid has to combine with phlogiston, even when superfluous water is mixed with it, furnishes many methods of producing abundantly this volatile vitriolic acid.

Stahl proposes two. The first is, by burning sulphur as slowly and gently as possible. The acid which exhales in this operation is very volatile, very phlogisticated, and very suffocating; for two reasons: 1. Because of the little activity with which the sulphur burns, the inflammable principle is not entirely consumed, but a portion of it remains united to the acid: and, 2. Because when the vitriolic acid, which in sulphur is in its highest degree of concentration, and even in a state of perfect dryness, disengages itself by degrees, during the slow burning of the sulphur; it finds in the air a portion of water which it greedily seizes, and which renders it fit to be changed with the remaining phlogiston into volatile vitriolic acid. When sulphur is burnt hastily and strongly, little or no volatile vitriolic acid is produced, principally because then almost all the inflammable principle of the sulphur is destroyed by this perfect inflammation.

This first method of obtaining the volatile vitriolic acid is the best and easiest, when it is not intended to collect it, but to apply it to some body as soon as it is produced; as, for example, to kill insects or noxious animals, to whiten wools and silks, to sulphurate wines, or to produce the sulphureous salt of Stahl. *See* SALT (SULPHUREOUS. *See* also SULPHUR). But this method is improper for collecting the volatile acid, because sulphur cannot burn in close vessels.

The second method proposed by Stahl for obtaining the volatile vitriolic acid, is by distilling green or martial vitriol in a cracked retort, to which a receiver is properly luted. By this method a considerable quantity is produced and collected; because, 1. The phlegm of the martial vitriol supplies the necessary water to the vitriolic acid; and, 2. Enough of the phlogiston of the burning coals passes through the crack of the vessel, to form volatile vitriolic acid. This method, though very good in itself, is subject to a very great inconveniency in practice; which is, that when cracked retorts are exposed to the fire with the greatest caution, they are very apt to break still more, and entirely to fall in pieces, by which the operation is spoiled.

This inconveniency may be avoided by distilling in a good retort, not cracked, a mixture of vitriolic acid, or substance containing it, and any matter capable of furnishing at once water and phlogiston. Thus spirit of wine, oils, fat, resins, &c. mixed and distilled with vitriolic acid, can always furnish a good quantity of strong volatile vitriolic acid. *See* OIL and ETHER (VITRIOLIC).

This acid ought to be kept in crystal glass bottles, closed exactly with glass stoppers; and to be as little as possible exposed to air, because vapors always exhale from it when so exposed, by which its strength is impaired from the dissipation of part of its phlogiston.

This great facility which the phlogiston has to separate itself from volatile vitriolic acid, is the cause of the exceeding difficulty, and even impossibility of determining precisely the quantity of phlogiston necessary to convert any given quantity of vitriolic acid into volatile vitriolic acid. In general, we know that very little is required; a single drop of oil being capable of converting, by distillation, a large quantity of vitriolic acid into very strong volatile acid.

It is no less difficult to determine certainly and precisely the properties of this acid as a menstruum of different substances; as, for example, earths and metals. This difficulty also proceeds from the facility with which it parts with its phlogiston, and consequently changes its nature, which it does more or less in the act of combination with the substances it dissolves. It is an acid perpetually changing, and which we cannot be certain of having the same at different times.

These difficulties ought not to prevent trials of such combinations, hitherto little known. Because in an important and essential enquiry, which may throw new light upon the theory of acids and phlogiston, even approximations become important and essential.

XIV. ACID (TARTAREOUS). *See* TARTAR, and CREAM of TARTAR.

XV. ACIDS (VEGETABLE). All acids obtained from vegetable matters are so called. Such are the juices of sour fruits, wine turned sour, or vinegar; crystals of tartar; all the essential, acid, concrete salts, procured by crystallisation from the expressed juices of plants; and lastly, all the acids obtained from vegetable substances in analysing them by distillation.

These acids differ from mineral acids in being less simple, less fixed, less susceptible of concentration and weaker; qualities, which proceed from their union to a certain quantity of oil, with which they are so intimately combined, that they cannot be separated from it but by very nice and studied operations. Hence all the neutral salts formed by these acids may be decomposed, either by the mere action of the fire, or by any mineral acid whatever.

The particulars of what is here advanced in general on their properties and principles, may be seen under the articles of the principal vegetable acids.

XVI. ACID (VITRIOLIC) was so named, because, formerly, it was chiefly obtained from martial vitriol. It is, according to the very probable opinion of Becker and of Stahl, the simplest of all acids, and consequently the simplest of all saline substances. When it is as pure as can be obtained, it is entirely free from smell and color; that is to say, in these respects, it resembles water.

It possesses most eminently all the properties characterising saline, and particularly acid substances.

It tastes exceedingly sour, and it sets the teeth on edge.

It changes to red the color of syrup of violets, of tincture of heliotropium, &c.

It is very susceptible of concentration; that is, much of the water unnecessary to its saline essence may be raised by distillation. *See* CONCENTRATION.

The specific gravity of this acid, when much concentrated, is very great. It is more than double the specific gravity of water, sometimes as 17 to 8, and perhaps might be further concentrated. M. Hellot, in pushing strongly the distillation of martial vitriol, obtained towards the end of the operation a vitriolic acid so concentrated, that it was solid and crystalline. Some chemists have given to vitriolic acid so concentrated as to become concrete, the name of GLACIAL, or ICY OIL of VITRIOL.

Vitriolic acid highly concentrated, is less fluid than water. It pours ropey like oil, and feels to the fingers greasy. These two last properties have occa-

 sioned

from the ancient chemists to call it *Oil of Vitriol.* This name is very improper, since it is not inflammable, nor has any peculiar properties of oils. *See* OILS. Its oily consistence is owing to the great approximation of its parts, and its apparent unctuosity proceeds from the same cause; joined to this, that as it is a very powerful dissolvent, it attacks and dissolves effectually a portion of the unctuous substance of the skin which it touches.

The very strong and concentrated vitriolic acid is not only much heavier, but also much more fixed than water. Hence it is capable of receiving, when exposed to fire, a degree of heat greatly superior to that of boiling water, and which almost amounts to a red heat.

This acid when well concentrated, (which we suppose here all along) unites itself to water with an astonishing activity and impetuosity. If two or three ounces of it be mixed with as much pure and cold water, the re-action of these two substances on each other is so strong, that instantly a boiling arises, attended with many vapors, and a noise similar to that of a red-hot iron plunged into water. The heat resulting from the re-action of these two cold liquors is so great, that in an instant it equals, and even much surpasses the heat of boiling water. Some chemists have attributed this heat to a disengagement of the igneous particles contained in vitriolic acid. This is not true, except they only mean the igneous particles contained in this acid, as in all other substances, and which are set in motion by all collisions; but not any superabundant igneous particles peculiar to this acid, since no experiment demonstrates their existence.

The concentrated vitriolic acid, exposed to the atmosphere, attracts moisture so much, that its bulk is considerably encreased, and it becomes mixed with twice its weight of water. *(p)*

It may be combined with the inflammable principle or phlogiston, and thereby form two compounds, differing from each other in the quantity of phlogiston, and in the closeness of the union.

The first, which is the result of a combination of weak vitriolic acid with a small quantity of phlogiston, is called volatile, sulphureous, or vitriolic acid. *See* ACID (SULPHUREOUS); and the second, which arises from an intimate union of vitriolic acid, freed from all water above what is necessary to its essence as a saline substance, with about a seventh part of its weight of pure phlogiston, is called *Sulphur.* *See* SULPHUR.

Earths are more or less soluble by vitriolic acid, according to their natures; and form with it different salts, or earthy saline compounds of different properties, according to the kinds of earths employed. Particular management is requisite to combine vitrifiable earths with vitriolic acid: and the salts resulting

(p) Dr. Gould relates, that three drams of concentrated vitriolic acid acquired by imbibing moisture from the air, in 57 days, an increase of six drams and a half; and that in general this acid acquires increase of weight in a compound ratio of the largeness of the surface exposed, and of the humidity of the atmosphere. Neuman found that an ounce of this acid, by exposure to air during a year, had imbibed more moisture than six times its original weight. For the method of obtaining this acid, *see* SPIRIT *of* SULPHUR, CLYSSUS *of* SULPHUR, and CONCENTRATION *of* VITRIOLIC ACID.

from

from their combination have not yet been sufficiently examined. *See* VITRIFIABLE EARTHS and LIQUOR of FLINTS.

Calcareous earths may be dissolved without any previous preparation by vitriolic acid. This solution is made with moderate effervescence; and from this combination results an earthy saline compound, susceptible of crystallization, whose principles are so intimately combined, that the saline properties of the vitriolic acid are almost entirely masked by those of the earth which is the prevailing principle (*see* AFFINITY); so that this neutral vitriolic salt with earthy basis has no sensible taste, and is scarcely soluble in water: according to Mr. Baumé's experiment, one grain only of it could be dissolved in an ounce of water. This want of saline properties, which appears common to all vitriolic salts with bases of calcareous earth, has occasioned them to be distinguished by the name of *Selenites*, from other combinations whose saline properties are more obvious. *See* SELENITES.

Alum is a vitriolic salt with earthy basis, but it differs considerably from Selenites. This difference proceeds from the nature of its earthy basis, which is not calcareous, but argillaceous. *See* ALUM.

Vitriolic acid may be combined and saturated with vegetable fixed alkali: and from this combination is formed a neutral salt, capable of being crystallized, bitter, hard, and not easily soluble in water. Several names have been given to this salt from the several substances whence its alkaline basis was extracted, at a time when these alkalies were supposed to differ from each other. These names are, *Sal de duobus*; *vitriolated tartar*; *arcanum duplicatum*. *See these words*, and ALKALI (VEGETABLE.)

With the alkaline basis of sea salt, called marine or fossil alkali, the vitriolic acid forms a neutral, crystalizable salt, called *Glauber's salt*, which differs from vitriolated tartar in the figure of its crystals, its greater solubility in water, the quantity of water contained in its crystals, and its property of drying in the air, or losing much of its water, by which the crystals lose their transparency, their solidity, and are reduced into a white meal, called *efflorescence*. *See* ALKALI (MARINE), and SALT *of* GLAUBER.

Volatile alkali combined to the point of saturation with a vitriolic acid, forms a neutral ammoniacal salt, and crystalizable, called *Salt (Vitriolic Ammoniac)*, *which see*, and ALKALI (VOLATILE).

Vitriolic acid being more simple and more powerful than the nitrous and marine acids, separates them from the alkalies to which they are united, and substitutes itself in their place. *See* NITRE and SALT (COMMON).

In general, this acid acts upon all metallic substances, and dissolves them with phenomena peculiar to each. It forms with them neutral salts with metallic bases capable of crystalizing; to all which salts M. Macquer thinks proper in his course of chemistry to give the general name of *vitriol*, and to specify the different vitriols by the name of the metallic matters which enter into their composition. Thus, for example, he proposes to call the combination of vitriolic acid with silver, *vitriol of silver*, or *lunar vitriol*; and the combination of the same acid with mercury, *vitriol of mercury*, &c. in the same manner as the neutral metallic salts formed by the union of vitriolic acid with iron and with copper, are called *vitriol of copper*, and *vitriol of iron*, or *martial vitriol*. *See* VITRIOL.

This acid, in consequence of its great affinity with the inflammable principle, attacks the phlogiston of metals when it dissolves them, and separates part of it from those which are capable of being deprived of it; consequently it calcines them more or less according to their nature, and to the manner of making the solution, and adheres to them proportionably less, as it has taken from them a greater quantity of their phlogiston. We may conclude from these phenomena, that vitriolic acid dissolves metals chiefly by means of their phlogiston; or that this principle is a medium of union between this acid and metallic earths.

The most general phenomena accompanying the solutions of metallic matters in vitriolic acid by the humid method, are, 1. The effervescence and heat, which are commonly moderate. 2. The vapors; many of which are the volatile vitriolic acid, as in the solution of mercury; or they are inflammable vapors, as in the solution of iron. 3. The formation of concrete sulphur, as in the solution of tin. See *the particular details of all these solutions of metallic matters by vitriolic acid, under the article of each metallic substance, and at the word* VITRIOL. (*q*)

It appears from what has been said on the combinations of vitriolic acid with all the substances with which it can form a neutral salt, that all these neutral vitriolic salts are susceptible of crystallization. This property is peculiar to vitriolic acid, and probably proceeds from the intimacy of union contracted betwixt this acid and the substances which it dissolves.

Concentrated vitriolic acid acts with considerable force on all oils and concrete oily matters. It boils and grows warm when added to them. It partly

(*q*) Diluted vitriolic acid dissolves iron and zinc speedily, and copper very slowly. Boiling concentrated vitriolic acid dissolves copper, and partly dissolves and partly corrodes silver, tin, mercury, and lead. Vitriolic acid does not directly dissolve gold, but precipitates it from aqua regia, which precipitate is soluble in vitriolic acid. It lessens the volatility of mercury and of arsenic; and the fusibility of lead, zinc, bismuth, and regulus of antimony. It dissolves the calxes of most metals. It also dissolves the semimetal, regulus of cobalt, but not nickel.

Although vitriolic acid has a strong power to combine with iron, yet its adhesion to it when dissolved seems to be very weak. Thus Mr. Margraaf found, that by boiling a solution of green vitriol in a copper vessel, or with filings of copper, part of the iron was deposited, and in its place part of the copper was dissolved. This experiment is so much more remarkable, as a diluted vitriolic acid has no sensible effect upon copper in a short time. The acid therefore by its previous solution of iron seems to have been so changed, as to be rendered capable of dissolving copper. This experiment does not contradict the general rule by which the power of union of vitriolic acid is affirmed to be greater to iron than to copper, but may be explained from the slight adhesion of the inflammable principle to the earth of iron; by which property salts formed by this metal with vitriolic or nitrous acids are continually decomposing; the phlogiston, which is the medium of union betwixt acids and earths, escaping into the air or combining with the acid, and the calx of iron separating from the acid, in form of a red sediment. This decomposition of martial vitriol, and martial nitre, and also of some other metallic salts subject to the same change, is accelerated by application of heat, air, moisture, and, as Mr. Margraaf's experiment seems to indicate, by the application of another metal, as copper. Mr. Margraaf has not given his sentiments concerning the cause of the alteration produced upon the acid in his experiment, by which it is rendered capable of dissolving copper. Is it by absorption of the phlogiston of the iron, that it becomes volatile vitriolic acid, and thereby acquires new properties as a menstruum?

decomposes them, blackens, and in some sort burns them. From these mixtures many fumes exhale, which have a mixt smell of burnt oil, and very suffocating volatile vitriolic acid. See the detail and explanation of these phenomena at the word OIL.

Vitriolic acid, when very weak, does not appear to have any action upon oils, because its superfluous water, with which it strongly adheres, hinders it from combining with these substances, to which the water cannot be united. However, the union of such a weak vitriolic acid with oil, does not seem impossible. *See* OIL.

Concentrated vitriolic acid shews, when mixed with spirit of wine, many very interesting phenomena, and which vary according to the proportions of these two acids, and the management employed.

Without distillation, it entirely combines in substance with spirit of wine, without occasioning any decomposition; that is to say, it does not combine with any of the principles of the spirit of wine preferably to the rest. It loses its acidity by this union, and is rendered greatly milder. Hence it is called *Dulcified Vitriolic Acid.* It has also been called WATER of RABEL; which *see.*

When spirit of wine and vitriolic acid are distilled together, the latter decomposes the former, takes possession of its aqueous principle, reduces a part of it into a middle substance betwixt ardent spirits and oil, to which the name *Ether* has been given; and lastly, the acid reduces the spirit of wine into a true oil, which has been improperly called *Sweet Oil of Vitriol. See* the words SPIRIT (ARDENT); ETHER; ETHER (VITRIOLIC); and SWEET OIL *of* VITRIOL.

Vitriolic acid is no where in nature found pure; that is, unmixed with any other matter. This proceeds from its capacity to dissolve, and to combine with a great variety of different substances.

Thus vitriolic acid is found naturally combined, 1. With an inflammable substance; then it is in form of sulphur or bitumen; or, 2. With earthy substances in form of selenites, aluminous and argillaceous matters; or, 3. With metallic substances, in form of natural vitriols; or, 4. With alkaline salts, in form of neutral vitriolic salts with alkaline bases. But it is almost only with the fossile or marine alkali that the vitriolic acid is ever found naturally combined, because this alkali is most generally diffused, and is indeed almost the only natural alkali. Vitriolic acid is therefore found in form of Glauber's salt. Natural Glauber's salt is chiefly found in those waters which contain common salt. *See* SALT (COMMON) and WATERS *of* SALT FOUNTAINS.

Vitriolic acid, combined with vegetable fixed alkali, forming vitriolated tartar; or with volatile alkali, forming vitriolic ammoniac salt, otherwise called the secret ammoniac salt of Glauber; can be found but very rarely, and by particular decompositions and combinations; as, for example, by burnings.

From what has been said concerning the states in which vitriolic acid is naturally and habitually found, we may perceive that it cannot be obtained alone and pure without particular artful operations; that is, by decomposing those bodies which contain most of it, and from which it may be easiest procured. These bodies are *Sulphur* and *Vitriols. See these words for the extraction of Vitriolic Acid.*

Upon

Upon considering the several substances with which vitriolic acid is found naturally combined, an interesting question arises concerning the original and primitive state of this acid. For as sulphur is spread in very large quantities within the earth, and that by its burning or decomposition, its acid separated from its phlogiston becomes capable of combination with earthy and metallic substances, as happens actually in the fabrication of vitriols and of alum; we may consider whether all vitriolic acid has been originally in the state of sulphur; and if one part of this sulphur being consumed or decomposed by natural causes, as happens in volcanos, its acid has formed all the vitriols and vitriolic salts with earthy bases, which are found formed in the earth; or whether, as we know by the experiment of the artificial composition of sulphur, that vitriolic acid quits every other substance in order to combine with phlogiston; all this acid was originally combined with earthy and metallic substances; and these vitriolic salts, meeting matters abounding in phlogiston, have been decomposed to form all the sulphur found in the earth. This question cannot certainly be decided but by the profoundest researches into the natural history of these several bodies.

The affinities of vitriolic acid according to Mr. Geoffroy's table are, phlogiston, fixed alkali, volatile alkali, earths, iron, copper, and silver: and according to Mr. Gellert's table, phlogiston, fixed alkali, volatile alkali, earths, zinc, iron, copper, silver, tin, lead, mercury, bismuth, regulus of antimony, and arsenic.

XVII. ACIDS (VOLATILE). Those acids are so called which are more volatile than most other acids; which volatility proceeds either from an union of some phlogiston, or of some attenuated oil. Such are the volatile vitriolic acid; the acid spirits of some acrid vegetables, as the roots of squills, according to Mr. Cartheuser; the acids which rise when butter or fat are distilled; and others similar.

XVIII. ADEPT is the name assumed by those alchemists who pretended to have discovered the philosopher's stone. *See* STONE (PHILOSOPHER'S).

XIX. ADOPTER. *See* RECEIVER.

XX. AFFINITY. By affinity *(r)* is understood that tendency which the constituent or integrant parts of bodies have to unite, and that power by which they adhere when united.

The definition of affinity shews that it is not a word void of meaning. The power with which the parts of bodies tend to unite with each other, and their adhesion when united, are very sensible and palpable effects, since this power cannot be destroyed but by another power as real and more considerable. It is

(r) By the terms *affinity* and *elective attraction*, we ought to understand the power by which the constituent parts of bodies unite, and not to suppose that this power is exerted by any similarity and homogeneity of parts, or by any mechanical traction, as these terms seem to imply. The cause of this power, or the manner in which this union of constituent parts, is produced, is unknown to us. To these terms, therefore, another less exceptionable, namely, *the power of combination*, may be substituted. In our author's definition of affinity is comprehended not only the power of union of the constituent parts of bodies, which is the proper object of chemistry, but also the power of union of the integrant parts of bodies, which he calls the affinity of aggregation, and which is treated of by writers on natural philosophy and mechanics under the terms attraction,

besides demonstrated by numberless experiments; as, for example, by the adhesion of two bodies applied to each other, whose surfaces are finely polished; by the tendency which two drops of water, or of oil, mercury, or of any other fluid, have to run together and unite into one mass; by the convex or spherical figure which drops of fluids assume, when their form is not given them by containing vessels or other body, and when they are supported by bodies with which they are not disposed to unite: all which effects happen even in a vacuum, and demonstrate the affinity which the integrant parts of bodies solid, or fluid, have to each other.

The affinity of the constituent parts or principles is demonstrated by the detail of all the phenomena in chemistry.

We do not here enquire into the cause of this great effect, which is so general, that it may itself be considered as the cause of all combinations, and may serve to explain them. It may perhaps be a property as essential to matter as its extent and impenetrability, of which we can say no more, than that such properties do exist. On this subject the works of Newton, Freind, Keil, and the Abbé Marcuzzi, may be consulted. These authors have endeavored to illustrate these obscure subjects by calculation. We shall be satisfied with observing the most remarkable laws, according to which the principles of bodies unite and combine, in consequence of this property.

M. Macquer distinguishes several sorts of affinities. Not that he believes there are distinct species of affinities; for it is very certain, that it is but one and the same property of matter, differently modified according to different circumstances; but only that he may better distinguish and remark the phenomena occasioned by this property, in the detail of the combinations and separations which it effects in the most general and most important operations of chemistry.

By *simple affinity* he means the disposition to unite and adhere, which is observed between the integrant and homogeneous parts of the same body, or between the heterogeneous parts of two different bodies. The simple affinity is therefore distinguished into two kinds.

The first kind of simple affinity produces the *union of aggregation*; that is to say, that the body resulting from this union is of the same nature, but of larger size. M. Macquer calls it the *affinity of aggregation*; as, for example, when several loose particles of the same metal or of the same earth are united together by fusion, so as to form but one mass. *See* AGGREGATION.

The second kind of simple affinity, producing the union and adherence of heterogeneous parts, different in their natures, from which results a new compound body, whose properties are different from those of the two principles

attraction, gravitation, and cohesion. Whether these two unions are produced from the same cause differently modified, as our author affirms, I know not; but their effects are so different, that they deserve to be considered separately: the union of integrant parts being only an apposition of these parts, which are capable of being disjoined by mechanical means, and without any change produced upon their properties; and the union of constituent parts, or combination, being attended with considerable changes of properties, and being incapable of disjunction by mechanical means. *See the article* COMPOSITION *of* BODIES, and the following *Note*.

from

from which it was formed, is called *affinity of composition*; because a new body is actually composed. If, for example, the primitive integrant parts of vitriolic acid be united with those of iron, a new body results from this union, which is neither vitriolic acid nor iron, but a compound of the two, called *martial vitriol*.

The following remarks may be made on simple affinities.

1. That the affinity of aggregation resists the affinity of composition. For it is evident that the force which makes the homogeneous and integrant parts of a body adhere together, hinders them from separating, in order to join the parts of another body.

2. Hence it follows, that if the adhesion of aggregation between the integrant parts of a body be weakened or destroyed, the affinity of composition is thereby facilitated; that is, the affinity which they have to join the parts of another body.

3. That as the hardness of a body supposed simple and homogeneous depends only on the adhesion of aggregation betwixt its integrant parts, if this adhesion be destroyed by separating these parts from each other; as by reducing them into fine powder, or still more by diffusing them in a liquid, with which they have no adhesion, or less than they had to each other; they may then be combined with the parts of another body, more or less easily, in proportion as they have been more or less separated by this mechanical division.

4. As different bodies are more or less susceptible of this mechanical division, whether artificial or natural, by which their integrant parts are more or less separated from each other, hence arises a great difference betwixt these bodies in their greater or less facility of combining with other bodies.

5. This facility of combining with another body does not, however, determine solely the degree of affinity betwixt these two bodies. For experience shews that principles or constituent parts of certain compounds, which unite together very readily and easily, have however but a weak adhesion, which is destroyed by the smallest effort of analysis, or chemical decomposition; while other principles which can be united only with great difficulty, and by studied means, contract together an union much stronger, and much less apt to be dissolved. Mercury, for instance, unites much more easily with nitrous acid than with the marine, but yet it adheres much more strongly to the latter than to the former.

Hence we ought to conclude, that we cannot positively determine that one body has no affinity with another body, because no means are known of uniting them. On the contrary, it appears certain that all natural bodies have a certain degree of affinity, and facility of uniting with each other, and a certain degree of adhesion when they are united, and consequently, that there are no combinations really and absolutely impossible; but that this degree of affinity varies according to the different states in which these bodies are found.

However, as the want of union betwixt two bodies prevents their affinity from shewing itself, we may consider bodies which we cannot combine as having no affinity together, until chemistry be so far advanced as to make combinations which now seem impossible. Thus, for instance, oil is said to have no affinity with water, nor lead with iron, nor iron with mercury; because, in fact, these bodies cannot be directly united together in chemical operations. Thus any affinity which they may have together is to us of no consequence.

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On the contrary, as the affinities of bodies which may be united together, produce in chemical operations effects proportionable to their facility of union, and to their force of adhesion when united, we may consider the affinity of bodies in general, as being in a compound ratio of these two properties.

The last remark we can make on the simple affinity of composition, furnishes a very useful and very general fundamental law, by which we may discover, even without decomposition, the principles of which bodies are composed. The remark is, that all compound bodies have properties partaking of the properties of the principles of which these bodies are composed. Thus, for example, the union of two principles, of which one is fixed, and the other is volatile, forms a compound, whose degree of fixity or volatility is intermediate betwixt those of the two principles.

The same may be said of all the other properties; such as gravity, opacity, transparency, ductility, hardness, fluidity, &c. and even of the affinities: so that, supposing we knew perfectly the properties of the principles of a compound, we might by examining the properties of this compound, discover its principles, even although its analysis were impossible.

We must however allow that this rule, although very general, is subject to a considerable number of restrictions and modifications, which depend on a number of particular circumstances. For example: it happens sometimes that the operation by which two principles are united changes or even annuls some of the properties of these principles: it happens too that sometimes their union developes new properties, which cannot be immediately perceived in either of the principles. But such changes are never so compleat as to lead one into gross mistakes concerning the principles; therefore they do not prevent the rule from being sufficiently general, to be an excellent guide in many chemical enquiries. (s)

Where more than two bodies act upon one another, the *affinity* may be called *complicated*; and from the definition given, it appears that all these complicated affinities must be of the kind called *Affinity of Composition.*

(s) The rule mentioned in the text is so far from being general, that perhaps the reverse of it may be considered as a general rule; and a change of properties, and a production of new properties, may be considered as criterions, by which compound bodies, chemically combined, may be distinguished from bodies formed merely by mixture or apposition of integrant parts; in which latter compound bodies, the properties are intermediate betwixt the properties of the several component parts, and no new properties are produced. Thus, three parts of copper combined by fusion with one part of tin, forms a body more hard, more brittle, and more sonorous, than either of the constituent metals. Its hardness, therefore, its brittleness, and its sonorousness may be considered as new properties. Its color is much whiter than the intermediate color, and its specific gravity is greater than the intermediate specific gravity. Further, the properties of bodies are in many instances destroyed or annulled by chemical combination. Thus the acrimony and deliquescency of acids and of alkalies are almost entirely annulled by combining these two kinds of substances together. Every body chemically combined may furnish facts which refute the general proposition mentioned in the text. Bodies formed by mixing, not by chemically combining several substances together; as, for instance, a liquor formed by mixing wine and water; partake of the qualities of each ingredient, proportionably to the quantity of it employed. *See* COMPOSITION *of* BODIES, *and* AGGREGATION.

First, we ought to consider that complicated affinity in which only three principles act. Experience indicates the following observations.

If a principle be added to two other principles united together, phenomena of composition or of decomposition happen, which differ according to the affinities of these three bodies to each other.

1. Sometimes the third supervening principle is united to the other two, and forms together with them a compound consisting of three principles. For example, if to a mass composed of gold and silver, some copper be added, this third metal is united to the other two, and forms with them a compound consisting of three principles, namely, gold, silver, and copper. Thus it happens, when the third supervening principle has with the two others an affinity equal, or almost equal to the affinity which these two principles have to each other.

2. The same thing also happens sometimes, although the third supervening principle has no affinity with one of the two principles originally united. But then it is necessary that this supervening principle should have, with the other of the two principles, an affinity equal to the affinity subsisting between those two principles originally united. And in this case, that principle which serves to connect and unite the two which could not otherwise be united, is called an *intermedium*. This affinity may also be called the *affinity of intermediums*. For example, if water be added to the compound called *liver of sulphur*, which consists of two principles, sulphur and fixed alkali, it unites with the water, dissolves in it without being decomposed, and forms a new compound consisting of three principles, namely, sulphur, fixed alkali, and water. The water and sulphur could not by themselves form any union: but as fixed alkali has a great affinity with both sulphur and water, it serves upon this occasion as an intermedium to unite these two substances together. It is necessary to remark, that in this affinity of intermediums, the affinity of the principle which serves as an intermedium is weakened, because it is divided betwixt two bodies; and that the union contracted with them is less strong than if it were united to one of them only.

3. Sometimes a third principle, when added to a compound consisting of two principles, does not unite but with one of these two principles, and obliges the other to separate itself entirely from the principle with which it was originally united. In this case a total decomposition happens of the first compound, and a new combination of the remaining principle with the supervening principle; from which a new compound results. This happens when the supervening principle has little or no affinity with one of the principles of the compound; and when it has with the other, an affinity much stronger than that which subsists betwixt the two first principles. For example, when an alkali is added to a solution of a metallic matter in an acid, as it has more affinity with the acid than with the metal, it seizes the acid, and obliges it to quit the metal, which therefore precipitates; because the metal has much less affinity than the alkaline salt has to the acid.

4. It happens sometimes that a principle, which, in consequence of the affinity we have been discoursing of, has been separated from another principle, may again resume its place with the principle, as it was originally, and dispossess the supervening principle. This affinity, which is called *reciprocal*, on account of

of its reciprocal effects, takes place when the two principles which are alternately separated from the third principle by each other, have with this third principle, an almost equal affinity, and that their separation is procured by particular circumstances relative to some of their properties.

All that has been said concerning the affinities of three principles may be applied to affinities of four principles, due regard being had to the changes produced by the introduction of a fourth principle. It is evident, for example, that in place of one decomposition and one new composition, which can result from the different degrees of affinity of three principles, the affinities of four principles forming two new compounds, may, by a mutual change, produce two decompositions and two new combinations. This always happens when the sum of the affinities, which each of the principles of the two compounds has with the principles of the other, surpasses the sum of the affinities subsisting betwixt the principles forming the two first compounds. This sort of affinity, where there is a double exchange of principles, may be called *double affinity*. Examples of these affinities are often met in chemical operations and mixtures; and without a knowledge of them, it would be impossible to explain many singular phenomena of decomposition. For example, it happens often that two principles, neither of which could singly effect the disunion of the principles of a compound, because their affinities are each of them inferior to the affinity betwixt the principles of that compound, become nevertheless capable of procuring this decomposition when they act in concurrence. For this purpose, it is sufficient, as we have already said, that the sum of affinities which the two decomposing principles have with the principles of the body to be decomposed, should surpass the sum of the affinity betwixt the principles of the decomposing body, and the affinity betwixt the principles of the body to be decomposed. See examples of this play of affinities at the words BLUE (PRUSSIAN), and SALT (NEUTRAL ARSENICAL).

We shall pursue no farther these remarks upon affinities; because the affinities of bodies compounded of many principles are much less strong and less sensible in chemical operations; or because this science is not yet sufficiently advanced to have observed and distinguished them all. What we have said is sufficient to form just ideas on the theory of all the important phenomena which are exhibited by the fundamental experiments, and to conduct to many new discoveries.

XXI. AGARIC. (*t*)

XXII. AGATE. (*u*)

(*t*) AGARIC is a fungus growing on the trunk of the common larch tree, from which turpentine is obtained. Three-fourths of it is a resinous substance, and the remainder is a slimy mucilaginous earthy matter, so tenacious as scarcely by any method to be dissolved by water.

(*u*) AGATE is a flint variegated with different colors blended together, and sometimes with colored lines and dendritical figures, as the *mocha stone*, which is a variety of agate, or with red spots, as the *sardea* or *St. Stephen's gem*, which also are varieties of this stone. For the chemical properties of agates, *see* EARTHS (VITRIFIABLE). By fire the *color* of a white agate, called *chalcedony*, was rendered whiter, and the color of a black agate was not changed. Colors may be given to agates, or their natural colors may be changed. Mr. du Fay, in the Memoirs of the Academy of Sciences, 1728, relates, that to chalcedony a saturated solution of silver in strong spirit of

XXIII. AGGREGATION. In order to have a clear idea of what chemiſts mean by the words *aggregation, aggregate, aggregated bodies*, we muſt attend to the difference betwixt what natural philoſophers call *conſtituent parts* and *integrant parts* of bodies. The conſtituent parts are, properly ſpeaking, the principles of bodies. Theſe are ſubſtances differing in nature from each other, which, by their union and mutual combinations really *conſtitute* mixed bodies, which partake of the properties of their conſtituent parts. For example, the conſtituent parts of common ſalt are an acid and an alkali, which ought to be conſidered as the principles of this ſalt. at leaſt as its proximate principles. *See* PRINCIPLES. As this acid and alkali are what really conſtitute common ſalt, and are the parts, to the union of which it owes its exiſtence and properties, it is evident that the conſtituent parts cannot be diſunited from each other, without deſtroying and decompoſing it: ſo that after ſuch a diſunion, the ſalt will no longer exiſt, but only the acid and the alkali of the ſalt, which are very different from the ſalt, and from each other.

On the contrary, the *integrant parts* of bodies do not abſolutely differ from each other; nor do they differ, as to the nature and principles, from the body into whoſe maſs they enter. By the integrant parts of a body are to be underſtood the ſmalleſt molecules or particles into which this body can be reduced without decompoſition. We may conceive that a neutral ſalt, for inſtance, common ſalt, may be divided into molecules ſtill ſmaller and ſmaller, without any ſeparation of the acid and alkali which conſtitute the ſalt; ſo that theſe molecules, however ſmall, ſhall always be common ſalt, and poſſeſſed of all its eſſential properties. If we ſhould now ſuppoſe that theſe molecules are arrived at their utmoſt degree of ſmallneſs, ſo that each of them ſhall be compoſed of one atom of acid and of another atom of alkali, and that they cannot be further divided without a ſeparation of the acid and alkali, then theſe laſt molecules are thoſe which Mr. Macquer in his Chemical Lectures calls *primitive integrant molecules.*

In the ſame manner that we conceive that a body may be divided into its primitive integrant molecules, without any change of its nature, or other alteration than a diminution of its bulk; ſo we may alſo eaſily perceive, that if theſe pri-

nitre gave a reddiſh brown color, to oriental agate a blacker ſtain, and changed the yellow ſpots of an agate to purple. The ſtone after the application of the metallic ſolution ought to be placed in the ſun; and the color may be rendered more intenſe by repeating the application of the ſolution. The liquor ſpreads ſo much on the ſtone, that neat deſigns cannot be made on it. Dr. Lewis propoſes to remedy this inconvenience by covering the ſtone over with etching wax, and the lines intended to be ſtained cut through this ground, in the manner of etching copper plates. The colors given to theſe ſtones may be deſtroyed by fire or by aqua fortis; and the colors thus deſtroyed by aqua fortis are recoverable by expoſure to the ſun. Agates and other ſtones may be ſtained black by applying to them a ſolution of copper in aqua fortis, and afterwards expoſing them to a red heat in a crucible. See *Lewis's Commerce of Arts.* Mocha ſtones may be imitated by moiſtening the ſmooth ſurface of an agate with a ſolution of copper, and on the middle of this ſurface ſetting an iron nail upright on its head. The iron abſorbs the acid from the copper, and the copper forms ramifications. If the nail be then removed, and the corroded iron carefully waſhed off by dipping the ſtone in water, the vegetations may be rendered by a red heat, of a black color. Theſe vegetations are not fixed in the ſtone, which ought therefore to be covered with a plate of cryſtal glaſs.

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mitive integrant molecules, which are all homogeneous and of the ſame nature, and which are ſuppoſed ſeparated from each other, ſhould be brought to unite and combine together, no new body, that is, a body of different nature, will reſult from this union, but only a more conſiderable maſs of the ſame body: that is to ſay, for inſtance, that if the primitive integrant molecules were common ſalt, their reunion would ſtill form common ſalt, only in a maſs ſo much larger, as there is a greater number of theſe molecules united together. But it is the union of theſe homogeneous parts, of theſe primitive integrant molecules, which modern chemiſts have called *aggregation*; and they have called *aggregates* bodies conſidered as reſulting from their primitive integrant parts, in oppoſition to the names *mixts* and *compounds*, which they have given to bodies conſidered as reſulting from the union of their conſtituent parts, which are ſubſtances heterogeneous, and of different natures.

The name of integrant parts, which has been given to thoſe whoſe union forms aggregates, agrees well with them; becauſe, in fact, this union is a kind of addition or integration (if ſuch a word may be uſed) of a certain number of parts of the ſame kind, whence reſults a ſum, or a whole.

It is very eſſential to obſerve on the ſubject of aggregation, that we ſhould have a very falſe idea of it, and entirely oppoſite to chemical phenomena, if we underſtood by this word nothing but a ſimple juxtapoſition of the integrant parts of bodies: for beſides that, there muſt be a real adheſion and intimate union of theſe ſame parts with each other, ſo that they cannot be ſeparated but by ſome force ſuperior to that by which they are united. A heap of ſand, for example, if we conſider the grains of ſand as its integrant parts, cannot be regarded as an aggregrate, becauſe theſe grains are only *juxtapoſited*, and have no real adheſion together; ſo that the reſiſtance which they oppoſe to their ſeparation can only proceed from their gravity, and is not the effect of adheſion, or tendency to each other.

In the ſecond place, it is neceſſary to obſerve on the ſubject of aggregation, that the force of adheſion of the integrant parts of different bodies varies much, according to the nature of theſe bodies, ſome of them adhering very ſtrongly, and others very weakly; and that thoſe which adhere weakly are generally the eaſieſt to be diſſolved, conſidering that the ſolution of a body, or its combination with another body of a different nature, cannot be effected but ſo far as the integrant parts of theſe bodies are ſeparated, or their aggregation broken; which is partly done by the operations of art, but chiefly by the action of menſtruums.

All theſe conſiderations on the aggregation of bodies, although very ſimple in themſelves, are of the greateſt importance in the theory and practice of chemical operations. Becker and Stahl were the firſt who explained theſe ideas, which have been ſince illuſtrated and extended by the beſt modern chemiſts. *See the words*, AFFINITY, COMPOSITION, SOLUTION, DECOMPOSITION, DIVISION *of* BODIES.

XXIV. AIR. Air is a fluid inviſible, inodorous, inſipid, imperceptible to all our ſenſes but the touch, and is conſidered as a ſimple elementary body, and primary principle, becauſe it cannot be altered or decompoſed by any known methods.

The air is always in form of a fluid, though perhaps that fluidity is not essential to it. But it is certain that no cold has ever yet been produced, natural or artificial, strong enough to deprive it of its fluidity.

We cannot flatter ourselves that we can have air, any more than the other elements, in perfect purity. On the contrary, it is always found mixed with more or less of foreign substances, proceeding from a perpetual exhalation of volatile matters, and particularly of water, with which it has even a certain degree of adhesion. *(x)*

The primary integrant parts of air, although certainly very small, yet are not so small as those of water, and even those of other liquids less simple, such as spirit of wine and oils: at least, these liquids pass easily enough through the pores of several substances, such as paper, the skin, &c. through which the air does not pass, or passes with difficulty.

The experiments of Mr. Boyle, and more particularly those of Dr. Hales, related in his Vegetable Statics, prove that most vegetable and animal matters contain a prodigious quantity of air; and scarcely credible, if the effects it produced were not so considerable and sensible. Chemical experiments also give us many occasions not only of observing these phenomena, but also of ascertaining the quantity of air disengaged, or absorbed in several operations. *(y)*

It appears that air, as well as other primary principles, is found in bodies in two different states: that is to say, that in certain bodies, and in certain circumstances, it is merely dispersed and interposed betwixt the integrant parts of those bodies, but without adhering to these parts, or at least adhering but very weakly. This air, which may be separated by means purely mechanical; such as the operations of the air-pump, compression, or shaking; and which besides possesses all its other properties; ought not to be considered as one of the elements of those bodies in which it exists. But that portion of air which cannot be separated from many bodies but by analysing them, and by employing such means of decomposition as chemistry furnishes; which, besides while it remains in those bodies, is deprived of one of its essential properties, its elasticity, which it does not recover till it is disengaged; this air, I say, ought truly to be considered as one of the elements or constituent parts of these bodies.

(x) Air not only *adheres* to water, as the text says, but chemically combines with it, and probably with many other volatile matters. The dissolving power of air, as of other menstruums, is encreased by heat; and hence upon an access of cold, the air deposits part of its water which it kept dissolved while its heat was greater. The water deposited becomes then visible, forming fogs, or condensing upon any cold body, as upon glass windows. This dissolving power of air is also effected by other circumstances besides heat: for we find that in equal heats air sometimes imbibes water faster than at other times. Dr. Gould found that vitriolic acid saturated with water by long exposure to air, did sometimes lose and sometimes gain weight, according as the air was disposed to deposit or dissolve moisture. By what circumstances this dissolving power of the air is effected, and how these various states of the atmosphere affect the health of vegetables and animals, are subjects worthy of enquiry.

(y) Whether the permanently elastic vapors produced in distillations and other operations be really atmospherical air altered by its union with the bodies from which it is disengaged, has not been hitherto shewn. It has been called fixed or fixable air. *See* AIR (FIXABLE).

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The properties of pure air, and which occasion many effects in chemistry, are:

1. Its *expansive power*; that is to say, that it is capable of great rarefaction, and of occupying a space thirteen times larger than its original size, when it is exposed to the greatest possible heat. This great expansibility of air, added to the prodigious quantity of it which is disengaged in many chemical analyses and mixtures, occasions frequently violent explosions, against which an intelligent artist ought always to be on his guard. *(w)*

2. Its *compressibility*; that is to say, that the effect contrary to that we have been mentioning, is produced upon it by means of cold and of pressure.

3. Its *elasticity*; which is nothing else than the force with which it endeavours to resume its natural condition, when it is violently rarefied, compressed, or condensed; and the effort which it makes for that purpose upon bodies which oppose its re-establishment.

4. Its *weight*; which determines it to fall impetuously into all the spaces into which it can have access, and which are unoccupied by air, or more ponderous bodies. The experiments which demonstrate all these properties of the air are so numerous and decisive, that nothing is better known and illustrated in natural philosophy. On this subject may be consulted the works of Pascal, Boyle, Mariotte, Abbé Nollet, and, in a word, of all the experimental philosophers. It is only necessary to observe here, that the specific gravity of air is to that of water, nearly as 1 to 850.

5. The faculty which the air has of considerably *facilitating the evaporation* of volatile matters sublimed by the fire. It is a well-established fact in chemistry, that the access of air greatly accelerates all evaporations and distillations. We see, for example, that by directing the blast of bellows upon the surface of any volatile body evaporating by means of fire, as water, antimony, mercury, &c. that the smoke or vapors of these bodies are very sensibly encreased. It is also certain that any distillation of a liquor, as of water, is much hastened, by directing upon its surface in the inner part of the alembic, the wind of a ventilator, as an English* author has proposed. *See* DISTILLATION and EVAPORATION. *(z)*

(*w*) Air is expanded $\frac{1}{3}$ of its bulk by the heat of boiling water. *See the History of the Academy of Sciences* 1699. Hales found that the air in a retort, when the bottom of the vessel was just beginning to be red-hot, was expanded to twice its former space, and in a white or almost melting heat it occupied thrice its former space or more; and Mr. Robins, a very accurate experimental philosopher, found that air was expanded by the heat of iron just beginning to be white to four times its size. As greater expansions cannot be well estimated, I presume there is an error in that part of the text to which this note refers, where the air is said to be capable of expansion to thirteen times its ordinary bulk.

(z) Air accelerates evaporation by its dissolving power, which is indeed the principal or only cause of evaporation, if by that word we mean the escape of any fluid with less heat than is necessary to convert it into vapor in a vacuum. By the same power air may also accelerate distillations, in which the heat is sufficient to raise the fluid into vapor in a vacuum; but if the air be cold, it will probably more impede the distillation by cooling the surface of the fluid, and condensing part of the vapor, than accelerate the escape of vapor by its dissolving power.

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6. Lastly,

6. Laftly, the moft fingular property of air, and at the fame time one of the moft interefting in chemiftry, is, that no combuftible fubftance can burn without its accefs; and that the more ftrongly it is impelled againft burning bodies, the more rapid is the combuftion. Hence it follows, that as the moft part of chemical operations cannot be performed without the affiftance of fire, a conftant current of air more or lefs ftrong, and in a certain direction, is neceffary to produce the heat requifite in thefe operations. Thefe currents of air are procured by bellows applied either to a forge, or to a melting furnace; or they are procured merely by the conftruction of the furnaces; which is done in fuch a manner, that by means of a fpace left in the upper part of the furnace, in which the heat keeps up a perpetual vacuum, the external air is determined and forced to enter by the afh-hole, to fill the vacuum above, and confequently forms a current which conftantly paffes through the fire, and which is fo much more ftrong and rapid as the vacuum of the furnace above is greater. That is a fundamental principle from which general rules may be deduced, applicable to the conftruction of all poffible furnaces. *See* BELLOWS, FORGE, and FURNACE.

Boerhaave, in his Treatife on Fire, and M. Geriké, Doctor of Phyfic, and Member of the Royal Academy of Berlin, who has alfo given a very large Differtation on Fire, in a very good work, printed in 1741, entitled *Fundamenta Chymiæ Rationalis*, are of opinion, that the accefs of air is neceffary to the combuftion of fubftances; becaufe, by its weight and fpring, it keeps the flame conftantly applied to the combuftible body, and encreafes their contact.

But this theory does not fufficiently explain why combuftible bodies may be kept red-hot in clofe veffels, without any confumption; becaufe then it cannot be doubted but that the matter of fire is, by the movement excited during ignition, continually applied and even impelled upon the combuftible body, without its burning or confuming. It has then all the appearance of a body burning and penetrated by fire, but it is by an extraneous fire that it is fo penetrated; its own inflammable matter is not confumed, and refts unalterable in midft of a moft intenfe fire.

However this be, it is very certain that the accefs of air is indifpenfibly neceffary to maintain the combuftion of bodies. But it is at the fame time very difficult to find the true caufe of this fact. The phenomena of combuftion feem to prove, that the air materially concurs to the production of flame, and makes a part of it: for a given quantity of air can maintain only during a limited and determinate time, the combuftion of a certain quantity of inflammable matter. If, for example, a lighted wax candle be placed under an inverted glafs bell, which is joined exactly to its fupport, the flame of the wax candle fubfifts during a certain time, fo much longer as the bell is larger, but conftantly diminifhing till at length it is extinguifhed; becaufe the quantity of air contained in the bell being a determinate quantity, and not capable of being renewed, cannot ferve but for a certain quantity of combuftion. Another phenomenon worthy of obfervation in this experiment is, that after the extinction of the wax candle, a real vacuum is formed under the bell, which is then as ftrongly preffed upon its fupport, as if a vacuum had been made by an air-pump; which proves demonftrably that the air which it included

included, materially concurred to the production of flame; since, if it were not so, the air being greatly rarified by the heat within the bell, would, on the contrary, make an effort to raise itself, and would escape violently as soon as it could. *(a)*

If we reflect but a little on these phenomena, many questions occur very interesting, but at the same time very difficult of solution. In fact, does the air, which disappears in this experiment, form a new compound with the inflammable principle of the burnt body by a new combination? If it be so, what is this compound? and what becomes of it? or is the air itself a necessary pabulum or food of flame? is it decomposed by the act of combustion? If so, the air, is not a simple body: what then is the nature of its principles? and what becomes of them?

XXV. AIR (FIXABLE). *(b)*

XXVI. ALABASTER. The name Alabaster is given to stones externally resembling marble; of a hardness nearly equal; but inferior, and

(a) A partial vacuum only is formed by this experiment. Dr. Mayow found that $\frac{1}{30}$th part of the elasticity of the air in a close vessel was destroyed by the burning of a candle till it was extinguished; and Dr. Hales found this diminution of elasticity of air, by the same means, to be $\frac{1}{26}$th part. Dr. Hales also found that $\frac{1}{30}$th part of the elasticity of air contained in a close vessel was destroyed by burning sulphur. All the air contained in close vessels in these experiments was not, however, rendered fixable by the burning of the candle till it ceased to flame; for Mr. Cavendish found that $\frac{1}{9}$th part of fixable air was sufficient to render a quantity of common air unfit for the maintenance of the flame of a candle. See Phil. Trans. 1766.

(b) AIR (FIXABLE). By this term we mean those permanently elastic vapors which are disengaged from almost all bodies when decomposed by distillation, from vegetable and animal substances by fermentations, and from many matters during their combination with other substances.

This subject is one of the most interesting in chemistry. Little more was known concerning it, than that permanently elastic fluids were producible from the substances, and by the methods mentioned in the above definition; till lately that the phenomena attending the combination of these fluids with, and their expulsion from, those substances, together with some other properties, have been investigated by experiments. The author of this Dictionary seems to have been unacquainted even with those discoveries which were published before this work. Of these the most important have been deduced by Dr. Black, from experiments so conducted and related, that his treatise may be considered as an excellent specimen of the best method of investigating and demonstrating chemical truths. *See Essays Physical and Literary, published at Edinburgh.*

The discoveries already made enable us to explain many chemical phenomena. We shall have frequent occasions to supply the defects of the text in this particular, and to correct some errors that prevailed in the theory of chemistry till lately. The subject is still new, and much may be expected from further experiments.

Some fixable air is *inflammable*, and some is *not inflammable*. We shall treat first of the latter kind, to which the name *fixed*, or *fixable air*, has been more peculiarly applied.

An uninflammable permanently elastic fluid may be produced by various methods, and from various substances. As the identity or diversity of the kinds of the several fluids thus variously obtained has not been yet ascertained, we shall mention what we know of each separately, distinguishing them only by the methods of their production.

1. A permanently elastic fluid may be obtained *from alkaline substances by combining these with acids*, or *by calcination*. Alkaline substances seem to have a power of combination with this fluid, and with it form compounds, some of the properties of which are different from the properties of these substances when uncombined. This power of combination

ſuſceptible of a ſimilar, but leſs lively and ſparkling poliſh. Some alabaſters are white; and others are veined and colored, like marbles. When theſe ſtones are well poliſhed, their ſemitranſparency, which is more ſenſible than that of marble, gives them the appearance of agates.

is nevertheleſs weaker than that which alkaline ſubſtances have to acids, nor is it ſtrong enough to reſiſt the action of fire. Hence this fluid or fixable air may be diſengaged from thoſe ſubſtances by acids, or by fire, when the alkaline ſubſtance is ſufficiently fixed to receive a violent heat. When alkaline ſubſtances have been by any means deprived of this fixable fluid, and are expoſed to an atmoſphere in which particles of it float, they readily abſorb it, unleſs they have been previouſly combined with ſome other ſubſtance, as an acid, with which they preferably unite, and again reſume their former ſtate. Hence all native alkaline ſubſtances are combined with this fluid. Thus, calcareous earth combined with this air forms the ſeveral maſſes of lime-ſtone, marble, chalk, and other ſtones and earths of this claſs. When any of theſe ſubſtances are deprived, by calcination or otherwiſe, of the fluid or air with which they are combined, they then become pure uncombined calcareous earth, or *quicklime*. Alſo fixed ſalts, obtained by incineration of veg are found to contain much fixable flu leſs they have been perfectly calcined; and volatile alkali, obtained by diſtillation of animal or of ſome vegetable ſubſtances, is ſaturated with this fluid. The principal differences which have been obſerved betwixt theſe ſubſtances combined, or not combined with fixable air, are, 1. By combination with fixable air they are rendered ſuſceptible of cryſtallization, which they are not wh n uncombined. Hence the uniform tex of marbles, calcareous ſpars, cryſtals of a rable or of mineral alkali, is y extrication of this air. 2. By n of alkaline ſubſtances with fixable air, it power of combination with all other s which are incapable of expelling from n this air, is diminiſhed. Hence, by this combination, the ſolubility of calcareous earth in water is deſtroyed: hence fixed alkali is leſs diſpoſed to deliquiate, or imbibe moiſture from the atmoſphere: hence vol alkali, which when combined is ſo ſtro diſpoſed to unite with water that it cannot be obtained in a ſolid or concrete ſtate, is rendered ſolid and cryſtallizable; hence the power of alkaline ſalts to diſſolve oil is greatly diminiſhed; ſo that ſoap-boilers find it neceſſary, in the preparation of ſoap, to deprive theſe ſalts, by quicklime, of all the fixable air with which they happen to be united: hence the cauſticity of calcareous earths is deſtroyed, and of alkaline ſalts is diminiſhed; and hence, theſe ſubſtances when combined with fixable air are diſtinguiſhed by the epithet *mild*, and when uncombined by the epithet *cauſtic*. 3. Alkaline ſubſtances combined with fixable air effervеſce with acids, which they do not, when rendered perfectly cauſtic; this effervеſcence being cauſed by the fixable air, which is diſengaged by acids from theſe ſubſtances.

This fixable air may be extricated from ſome alkaline ſubſtances by others, with which it has a ſtronger power of combination, and with which it does then actually combine. Thus mild volatile alkali may be deprived of its air, or rendered cauſtic by plying to it uncombined magneſia, fixed ali, or calcareous earth, while theſe ſtances unite with that air, and are therendered mild. Magneſia may be deprif its air by cauſtic fixed alkali and calous earth; and laſtly, mild fixed alkali be rendered cauſtic by quicklime or cauſtic calcareous earth, which is thereby rendered mild. Thus by adding a mild fixed alkali to lime-water, which is a ſolution of cauſtic calcareous earth in water, the calcareous earth will take the fixable air from the alkali, will become mild, conſequently unſoluble in water, and hence will be precipitated.

Fixable air has a weaker power of combination than acids have with alkaline ſubſtances; hence theſe ſubſtances may be deprived of their fixable air by acids; and accordingly, when calcareous earth is precipitated from marine acid by a cauſtic alkali, it is found to be in a cauſtic ſtate, or quicklime.

The quantity of fixable air contained in marble was found by Mr. Cavendiſh (Phil. Tranſ. 1766) to be $\frac{408}{1000}$ of the whole; in

Naturalists disagree in their opinions about the kinds of stones which ought to be called *alabasters*. For some authors give this name to certain stones which are absolutely calcareous, while others give it to stones of a gypseous nature. Of the latter class of naturalists is Mr. Pott, who admits no calcareous alabaster, and

volatile sal ammoniac, $\frac{525}{1000}$; and in crystals of salt of tartar $\frac{423}{1000}$.

The specific gravity of this fixable air was found by Mr. Cavendish's experiments to be to that of water as 1 to 511, or to the specific gravity of atmospherical air, when this is 800 times lighter than water, as 1 $\frac{57}{100}$ to 1.

This fixable air is noxious to animals, and extinguishes flame. These properties probably do not proceed from its interception of common air, but from some peculiar quality; for Mr. Cotes found by experiments, that fixable air was more injurious to animals than a vacuum; and from Mr. Cavendish's experiments we find that $\frac{1}{9}$ of fixable air, mixed with atmospherical air, occasioned the extinction of the flame of a candle.

2. A permanently elastic fluid or fixable air is produced *by dissolving metallic substances in acids*. From iron, zinc, and tin, dissolved in the vitriolic or marine acids, an inflammable air is produced, of which we shall treat afterwards. From all other metallic substances, and from these above mentioned dissolved in other acids, uninflammable airs are produced. An air also adheres to metallic substances precipitated by mild alkalies or earths, which they receive from these precipitating matters, and which gives them greater than their original weight. To adhering air Dr. Black attributes the fulminating property of the precipitate called *fulminating gold*.

3. An elastic fluid or fixable air is produced *by combining concentrated acids with oils and resinous substances, with spirit of wine and with water*. These substances are also capable of absorbing the fixable air of alkaline matters. Thus oil of olives was found to absorb an equal bulk of it; spirit of wine 2½ times its bulk, with the heat of 46° of Fahrenheit's thermometer. Water also absorbed this air more copiously in cold than in hot weather. With a boiling heat, and even by exposure to common air during a few days, it parted with the air it had absorbed.

4. A fixable air is obtainable *from animal, vegetable, and some mineral substances by distillation*. By this method Dr. Hales procured from a cubic inch of deer's horn thirty-three grains of air, from Indian wheat $\frac{1}{4}$ of its weight, from well-water $\frac{1}{6}$, from Pyrmont water $\frac{1}{13}$, from nitre $\frac{1}{8}$, from tartar $\frac{1}{3}$, and from salt of tartar $\frac{1}{6}$ of the respective weights of these substances.

5. A fixable air is extricated from water merely *by taking off the pressure of the atmosphere*. An air may also be extricated by the same method from lime-water, which must be different from the air of alkaline substances, else it would precipitate the calcareous earth from the water, as Dr. Black has remarked.

6. Fixable airs are produced by the *vinous, acetous, putrefactive, and probably by all other fermentations*. Dr. Hales found that 42 cubic inches of ale, which had been fermenting thirty-four hours, did continue to emit air from the 2d of March to the 9th of June following, sometimes more and sometimes less according to the heat of the weather; and that upon a sudden change of weather from hot to cold, it resorbed air. The whole quantity of air emitted was 639 cubic inches. These airs are also deleterious to animals, and extinguish flame.

7. *Atmospherical air is rendered unfit for respiration, or combustion, by having been inspired by animals or vegetables*, and is therefore probably reduced to the same, or to a similar state with some of the above mentioned fixable airs.

8. *Atmospherical air is rendered unfit for respiration or further combustion, by having assisted the combustion of ignited inflammable bodies*. A considerable part also of its elasticity is destroyed by this combustion: for by burning a candle in a close vessel till it ceased to burn from want of fresh air, the air contained in the vessel lost, according to Dr. Hales, $\frac{1}{20}$th, and according to Dr. Mayow, $\frac{1}{30}$th part of its elasticity. These effects are not produced upon air merely by heat; for we find from Mr. Hawksbee's experiments, that air was not altered by passing through a heated glass tube, but was rendered noxious to animals by passing through heated tubes

firmly maintains his opinion in his Lithogeognosia against Linnæus, Konig, Bruckman, and several other authors, who class alabaster along with marbles and calcareous stones.

It cannot be doubted that the stone which Mr. Pott called alabaster, and which he chemically examined, is actually gypseous. His experiments evidently

of brass and iron; glass being an incombustible substance, and metals, at least those called *imperfect*, being capable of calcination, which is a combustion, or dissipation of their inflammable principle. Whence does this alteration of atmospherical air proceed? Is it that part of the atmospherical air is converted into fixable air, by combining with the phlogiston or some part of the burning substances?

o A permanently elastic fluid or fixable air is produced *by deflagration of nitrous acid with any inflammable substance*. In this operation the acid disappears, and an elastic vapor is produced. May we not thence infer, that the acid is converted by combination with some other substance, probably with the inflammable matter, or by decomposition of its own substance, into elastic vapor? The author of this Dictionary in the article DETONATION OF NITRE adopts the opinion of Stahl, that the explosion of nitre with inflammable matter is produced by rarefaction of water contained in nitre or its acid. This rarefaction does contribute to the effect produced, but is not the sole or principal cause: for the vapor of water is condensible by cold into a liquor similar to the water from which it was formed, whereas the vapor of which we now treat is permanently elastic. Stahl did indeed maintain that the water was by this operation changed into air; but we have not sufficient reasons to believe the possibility of such a conversion in any instance; and in this instance we know that the water of the nitre is, after the explosion, condensed, and forms what is called a *clyssus*. See CLYSSUS OF NITRE, and DETONATION OF NITRE.

This elastic fluid was found by Mr. Robins to occupy, when compressed by the atmosphere and reduced to the same heat, a space equal to 250 times the space occupied by the gun-powder before explosion. And as the elasticity of air appeared from his experiments to be encreased four times by the heat of iron just beginning to be white; if this fluid be equally affected by heat as air is, its elasticity in the instant of explosion is about 1000 times greater than the pressure of the atmosphere; a force sufficient to produce the effects of gun-powder.

These are the known kinds of permanently elastic fluids extricated from substances, in which they existed so combined, that their elasticity was either destroyed or counteracted by a superior force. The properties of these fluids have not been sufficiently investigated, to enable us to determine whether all or several of them be of the same or different kinds. Do not, however, the elastic fluids produced by combustion, and extricated from alkaline substances, seem to be of the same kind, since a caustic alkali may be rendered mild by exposure to the former fluid? Are not these two elastic fluids probably of the same kind with that obtained from some metals; or, at least, have they not some principle common to them all, since metals deprived of their fixable air, or of the principle which renders atmospherical air fixable, by calcination, or by solution in acids, may be reduced to their proper metallic state by applying combustible substances; and since several instances are given, by authors, of the reduction of metallic calxes by chalk, and other mild calcareous earths? Have not the fluids separable from alkaline and metallic substances some analogy with acids? Like acids, they readily unite with, and effect the crystallization of those substances. As a weaker acid is extricated from those substances by a stronger, so is this air by all known acids. Are not the elastic fluids produced by the deflagration of nitre, and by the combustion or alkalization of tartar, and of other vegetable acid salts, formed from the acids of these substances combined with the inflammable principle? Whether these or many other conjectures, which might be made, be just or not, we may easily perceive that a judicious prosecution of this subject may tend to explain many important facts in chemistry.

Concerning

demonstrate it. But, on the other side, it does not appear less certain, that the name *alabaster* has been very anciently given to stones undoubtedly calcareous. The greatest part of the antique vases and busts, although universally called alabaster, are of this kind. They are readily and entirely soluble in spirit of nitre with great effervescence, and are convertible by fire into quicklime.

The truth is, that sculptors and artists, who work upon marble and alabaster, seem to have given indiscriminately the name *alabaster* to stones which have only an external resemblance to each other; that is to say, to stones which, to the other external qualities of marble, join also a more crystalline and more transparent appearance. Thus these artists have confounded under one name stones of very different kinds; and hence, among those called alabasters, some are truly calcareous, and others entirely gypseous. Therefore if stones are to be named from their external appearances, we ought, in order to avoid a confusion of two substances entirely different, to admit two kinds of alabasters; one kind calcareous, of which the greatest part of vases and busts are made which are called alabaster; and the other kind gypseous, which is also used in sculpture, and is that which Mr. Pott examined, and to which he assigns exclusively the name alabaster.

These difficulties being explained, chemists and naturalists are at liberty to take which side they please. They will always be understood when they distinguish in this manner the substances concerning which they write.

This being established, the kind of stone which may be called calcareous alabaster, has essentially all the properties of calcareous stones; for which reason, it is necessary to consult, upon this subject, the articles EARTHS (CALCAREOUS) and QUICKLIME. We shall only observe here, that it appears demonstrated, as M. d'Aubenton has advanced, that the differences observable betwixt calcareous alabaster and marble, proceed only from the different manners in which these

Concerning the *antiseptic* qualities of fixable airs, *see* PUTREFACTION.

Inflammable permanently elastic fluids may be obtained by dissolving zinc, iron, or tin in marine or dilute vitriolic acids. 356 ounce-measures of air were obtained from an ounce of zinc dissolved in vitriolic acid, and also from the same quantity of zinc dissolved in marine acid: 412 ounce-measures of air were obtained from an ounce of iron dissolved in vitriolic acid; and 202 ounce-measures of air from an ounce of tin dissolved in marine acid.

This inflammable air was not absorbed by water, or by fixed or volatile alkalies.

Like other inflammable substances, it is only combustible by access of atmospherical air, of which it requires an equal quantity for that purpose.

It was found by experiment to be eleven times lighter than atmospherical air, when the weight of this was to that of water as one to 800. Hence the quantity of air obtained from zinc, as above mentioned, was nearly $\frac{1}{24}$th part of the semi-metal.

An inflammable permanently elastic air is also producible from putrefying vegetable and animal substances. One grain of this air was obtained from 7640 grains of putrefying gravy broth, which contained about 163 grains of solid matter. The loss of weight sustained by this broth was much greater. The remaining part must have been according to Mr Cavendish (from whose paper on factitious air, Phil. Trans. 1766, all the above mentioned facts on inflammable air are copied) uninflammable fixable air, and some matter which communicated color and smell to soap-leys.

An inflammable permanently elastic fluid is frequently observed in mines, and is dangerous to miners. These fluids are called *Damps*. See *the article* DAMPS.

two

two substances are formed; marble being of ancient formation, and the product of a deposition of calcareous particles accumulated upon each other in banks and large masses: while calcareous alabaster is formed also of calcareous particles, but in the way of filtration; and of *stalactites*, of which large enough masses are found to make vases, busts, and even statues. This difference in the formation of these two matters is sufficient to explain the cause of the greater transparency of calcareous alabaster. In fact, if a piece of calcareous stalactites be cut and polished, no difference can be perceived betwixt it and works made of calcareous alabaster.

As to the stone called *gypseous alabaster*, it has all the properties of gypseous stones, and therefore it is necessary to consult upon this subject the articles GYPSUM and PLASTER.

XXVII. ALCHEMY. This term has been employed by the pretended adepts, and by searchers after the philosopher's stone, to distinguish that kind of chemistry the knowledge of which they flattered themselves was reserved for them alone. The adepts consider chemistry as a vulgar science, which scarcely contains the first elements of the mysterious science of alchemy. But hitherto they have produced nothing which, in the judgment of sensible men, can give the least grounds to such a pretension. True chemists consider alchemy as an imaginary science, and those who are devoted to it as persons who, from want of better instruction, quit a reality for the sake of a shadow.

XXVIII. ALEMBIC. An alembic or *still* is a vessel employed in distillations. There are several kinds differing from each other, either as to their form, or the matter of which they are composed.

The most frequent use of alembics is for distillations of very volatile principles drawn from several substances, particularly from vegetables. When the principles intended to be procured by distillation have no considerable action upon metals, and when they are susceptible of rising with a degree of heat which does not exceed, or but little, the heat of boiling water, copper alembics well tinned in their internal surface are employed.

The most convenient of these alembics, and which may be employed for many kinds of distillation, are composed of the following pieces. The first is a kind of pot designed to contain either the matters intended for distillation, or water, in which is immersed another smaller vessel of the same form, and made to contain the matters intended for distillation by the water-bath. These pieces of the alembic are called in general *cucurbits*, because formerly they were of an oblong form, upright, contracting themselves in their upper part, and diminishing into a kind of neck, which made them resemble a cucurbit, or gourd, or a *bladder*, by which latter name also they have been distinguished.

The cucurbits of copper alembics used now have no resemblance to this form: on the contrary, they are broad, not very deep, and wide. This new form of cucurbits is much more advantageous, as by it the distillations are much accelerated, with equal heat. The reason of this is, that the quickness of distillation is always proportionable to the quickness of evaporation; and that as evaporation is always made at the surface of bodies, the more surface these bodies present, the more quick and easy will be the evaporation. But the broad and wide form of modern cucurbits is infinitely more proper for the exposing of much

much surface of the bodies contained, and particularly of liquid bodies, than the form of the ancient cucurbits, which were high and strait.

The first of these two pieces is of copper, that it may resist the action of the fire: the second is generally of tin, and ought to be so shaped, that it can enter exactly into the former piece, and that they should fit so well as to render any luting unnecessary.

There ought to be a small pipe or neck at the upper part of the first piece, which may be exactly closed, and through which water or other fluid may be introduced at pleasure.

The third piece of the alembic is called the *capital*, because it is a kind of head. This piece has the form of a hollow cone. It is furnished with a gutter or channel, which is placed along its inner and lower circumference.

This capital has also in its lower part a kind of neck, which ought to enter so exactly into either of the two former pieces, as no luting shall be necessary. Lastly, it ought to have a pipe, called the *beak*, which opens inwardly into the gutter.

This beak ought to be from fifteen to eighteen inches externally, and so inclined, that it shall make with the neck of the alembic an angle of about sixty degrees.

The fourth piece of a copper alembic is called the *refrigeratory*. It is a kind of bucket, surrounding the capital, to which it is exactly soldered in its lower part. In this, near its bottom, is inserted a cock. The use of the refrigeratory is to contain cold water to facilitate the condensation of vapors circulating in the capital. Its cock serves to empty the water when it is become too hot, that it may be supplied with cold.

As in copper alembics the refrigeratory and capital are joined, they may be considered as making only one piece. However, it is necessary to distinguish them; first, because their uses are very different; and, secondly, because the refrigeratory is not essential to the alembic. Several chemists, good operators, are doubtful concerning its utility, particularly since the custom was introduced of applying worms to alembics.

The *worm* is a long, tin, spiral pipe, included in a copper bucket, so that its upper and lower extremities shall come out of the bucket by two holes, round which they are well soldered. The upper extremity of the worm receives the beak of the alembic, and its lower extremity enters into a receiver fitted to it. The bucket containing the worm is filled with cold water, which cools and condenses the vapors passing through it. The principal advantage which this refrigeratory has over that surrounding the capital, is, that it is not subject to retard or even to stop the distillation, as this latter one is: for this inconvenience has been observed to happen, whenever the capital of the alembic has been exposed to a certain degree of cold. There is in M. Beaumé's Elements of Pharmacy a very exact description, and a good engraving of a copper alembic with its worm.

The alembics described are of great use for the distillation of the *spiritus rector* of vegetables, of their *distilled waters*, of their *essential oils*, of pure *ardent spirits*, of spirits charged with the odoriferous principles of plants, and also for many other distillations of this kind. But as it is frequently necessary to distill in alembics acid and saline liquors capable of attacking metals, glass alembics are employed

employed for ſuch diſtillations: and theſe are generally compoſed of only two pieces, namely, a cucurbit, and a capital, which is fitted above and joined by luting. There are glaſs cucurbits, high and ſtrait, which may be uſeful for the diſtillation of certain very volatile ſubſtances. Others are made ſhallow and broad, and theſe have the ſame advantages from their form as the metal ones have.

To avoid the luting of the capital with the cucurbit, theſe glaſs alembics have been made of one entire piece. The capital of theſe alembics, which are of cryſtal glaſs, ought to have an opening at its top, which may be exactly cloſed with a cryſtal ſtopper ground with emery. This opening is intended for the introduction of matters to be diſtilled, and for the extraction of the reſiduums after diſtillation. Theſe alembics of one piece, although ſometimes convenient, are ſeldom employed on account of their dearneſs, and of the difficulty of introducing, and of extracting ſolid matters.

There are alſo made cucurbits of ſtone-ware, and of glazed earthen ware, which are uſeful in many caſes. *See* at the word DISTILLATION ſeveral obſervations relative to the form and matter of alembic. *See Plate* I.

XXIX. ALKAHEST. This is a name given by ancient chemiſts to a pretended univerſal menſtruum. Such a menſtruum either does not exiſt, or elſe there is not any body in nature which may not become an alkaheſt. For although certain ſubſtances have not hitherto been combined with others, the daily diſcoveries in chemiſtry of combinations formerly believed impoſſible, ſeem to prove, that by certain management, and certain circumſtances, any ſubſtance may be combined with all others; or, in other words, that all bodies may be diſſolved by any ſingle ſubſtance. (*c*)

XXX. ALKALESCENT. This word is employed to denote a matter ſlightly alkaline, or which begins to turn to the alkaline and putrid fermentation.

XXXI. ALKALI (FIXED). Fixed alkali is a ſubſtance compoſed of acid, of earth, and of a little phlogiſton; and whoſe principles have to each other a weaker adheſion, than the principles of any acid have to each other. There are ſeveral kinds of ſaline alkaline ſubſtances. Theſe are vegetable alkali, mineral or foſſil alkali, and volatile alkali. They are all called by the general name *Alkali*, becauſe the following properties are common to them all.

1. Alkalies may eaſily be obtained dry and concrete, and freed from all water unneceſſary to their ſaline eſſence. (*d*) When they are in this ſtate,

2. They produce heat by adding water to them.

3. They attract the moiſture of the air, and deliquiate into a liquor. (*e*)

4. They change the color of ſyrup of violets into green, whether they be dry or fluid.

(*c*) Kunckel very well ſhews the abſurdity of ſearching for an univerſal ſolvent by aſking, "If it diſſolves all ſubſtances, in what veſſel can it be contained?"

(*d*) Volatile alkali retains water ſo ſtrongly that it cannot be obtained dry, unleſs by combining it with fixable air, and then it becomes cryſtallizable. The fixed alkalies may be rendered dry by application of heat, but are only chryſtallizable by help of fixable air. *See* AIR (FIXABLE).

(*e*) Mineral alkali does not deliquiate by expoſure to air; but on the contrary, when chryſtallized, it becomes dry, and loſes the water which is neceſſary to its chryſtalline ſtate.

5. They

5. They have an acrid, burning taste, so much stronger as they are purer and dryer. This taste has something *urinous*: and hence they are called by some chemists *urinous salts*. They are also called *lixivial salts*, because the method of obtaining fixed alkalies consists in lixiviating the ashes of certain vegetable substances.

6. They partly exhale with water, particularly when boiled in open air.

7. When they are dryed and re-dissolved, some earth is always separated from them.

8. They may be fused by a moderate heat.

9. When fused, they dissolve all earths.

10. When added to earths and particularly to those called vitrifiable earths, and exposed to a sufficient degree of heat, they and the earths become glass. *See* VITRIFICATION.

11. When added in a large proportion to the earths, with which they are fused or vitrified, they communicate to these earths all their own properties. *See* LIQUOR OF FLINTS.

12. They effervesce and unite with acids to the point of saturation more perfectly and more intimately than pure absorbent earths, and from this union result different neutral salts.

13. They decompose all salts with bases of earths, metals, or volatile alkali. They separate these bases, and unite with the acids of the salts, with which they form new neutral salts. This is an example of stronger affinity, from whence result a new decomposition and a new combination.

Alkaline salts being substances pretty simple, as well as acids, are powerful solvents. They are capable of combining not only with all acids and with all earths, as we have said, but also with sulphur and with oily matters. With sulphur they form a sulphureous soap, soluble in water, called *liver of sulphur*; which *see*.

With oils, fat, resins, &c. they form compounds, which have been called *soaps*. In each of these combinations, the alkali is a medium by which the inflammable substance, naturally unsoluble, and even immiscible in water, becomes miscible and soluble in that liquid. *See* SOAP.

These saline substances can act also upon spirit of wine, when they are deprived of all the water unnecessary to their essence as salts. Alkalies, in that state, applied to spirit of wine, first deprive it of its superfluous water; afterwards, when in a proper proportion, they act upon its own substance, by combining with it, and causing several alterations, and even a decomposition of its parts. *See* SPIRIT *of* WINE (TARTARISED), and TINCTURE *of* SALT *of* TARTAR.

Lastly, alkalies act upon metallic substances with more or less facility, according to their natures, and the different means employed; which shall be mentioned under the several articles of the alkalies and metals.

N. B. All that has been said above concerning alkalies, may be applied to all the several kinds of alkalies, even to those called *volatile*, excepting those properties which depend upon fixity. Hence this article is applicable to alkalies in general. But it is necessary to observe, that a very just idea cannot be formed of these generalities, without entering into the details of what concerns the several kinds. *See* for the *affinities* of fixed alkali, and for its *medicinal virtues*, the word ALKALI (FIXED MINERAL).

XXXII. ALKALI (FIXED VEGETABLE). This name is given to all fixed alkalies obtained by burning any vegetable ſubſtances, and which have not the properties of the alkali, which is the baſis of common ſalt, which has been called the alkali of common ſalt, the *marine alkali, mineral or foſſil alkali.*

The common method of obtaining fixed alkalies from vegetable ſubſtances, conſiſts in burning theſe ſubſtances freely and in open air, till they be reduced to aſhes. *See* COMBUSTION *of* PLANTS. After which theſe aſhes are lixiviated with very pure water, till the water comes from them inſipid. This lixivium is evaporated to dryneſs; and what remains is the fixed alkaline ſalt of the plant, which may be deprived of its ſuperfluous water and ſuperfluous phlogiſton by calcination with a long and gentle fire.

Fixed alkalies obtained from any vegetable matters when well prepared and carefully purified by means hereafter to be deſcribed, are all exactly alike, and have the ſame properties; ſo that they are only one and the ſame kind of ſaline ſubſtance. But as it is very difficult to procure this ſalt in its utmoſt degree of purity, and as, in this reſpect, there is a difference betwixt thoſe obtained from different vegetable matters, ſome of them being naturally purer or more eaſily ſuſceptible of purification than others; and further, as ſufficient attention has not been given to the means of perfectly purifying theſe alkalies, two inconveniences have happened. The firſt is, that ſeveral chemiſts have imagined that there was an eſſential difference betwixt alkalies obtained from different plants: and the ſecond is, that other chemiſts have attributed to alkalies in general, ſeveral properties not belonging to them as alkalies, but to certain foreign ſubſtances adhering to them. We here conſider the vegetable alkali perfectly purified: and after we have enumerated its principal properties, we will treat of its origin, of its formation, and of the means of purifying it.

Fixed vegetable alkali has all the properties related under the article ALKALI (FIXED).

It is ſolid or concrete, like an earthy ſubſtance; of a fine white color; without tranſparency, or cryſtalline and regular ſhape, becauſe, in fact, it is not ſuſceptible of cryſtallization *(f)*; of no ſmell while it is dry, but of a ſlight lixivial ſmell when moiſtened with water. It has a violent, ſharp, burning, cauſtic and urinous taſte; that is to ſay, that when put in the mouth, it diſcovers a taſte of putrefied urine, which is cauſed by the diſengagement of volatile alkali from animal ſubſtances.

Here it is proper to obſerve, that when it is required to taſte fixed alkali, it is convenient to diſſolve and dilute it in much water, which only leſſens its ſtrength without altering its character: otherwiſe, the tongue might be bliſtered, becauſe calcined alkali is powerfully cauſtic, and quickly corrodes and deſtroys all animal matters. *(g)*

Fixed alkali, expoſed to air, attracts moiſture, with which it reſolves, or deliquiates into a white tranſparent colorleſs liquor like pure water. Fixed alkali

(f) Fixed vegetable alkali does not ſo readily cryſtallize as mineral alkali does. It is nevertheleſs cryſtallizable by expoſing it to fixable air, with which it combines and forms cryſtals. *See* AIR (FIXABLE).

(g) The cauſe of this is, that by calcination fixed alkali is deprived of a part of its fixable air, and is thereby rendered more ſoluble, and conſequently more cauſtic. *See* AIR (FIXABLE).

attracts

attracts thrice its quantity of moisture, according to Geller. *Chemie Metallurgique, Tom.* 1. *p.* 26.

The same thing happens if it be purposely dissolved in water. But in this latter case, at the first instant of the mixture, a pretty strong heat is excited, by the activity of the union of alkali and water. This heat, however, is much less than what arises from the mixture of concentrated vitriolic acid and water.

Every time that fixed alkali is dissolved in water, a portion of indissoluble matter remains. If the solution be filtered, it passes very clear: but after some time, it begins to be turbid, and small flocks are formed in it of a matter which falls to the bottom of the vessel, and cannot afterwards be redissolved. This matter is of the same nature as the first substance which we observed remains undissolved; and is nothing else than a portion of the earth of the alkali, which is separated every time that the salt is calcined and dissolved. The part which at first passes through the filter, and which afterwards renders the liquor turbid, is that part which was the most attenuated, and most adhering to the alkaline salt. This earth thus separated, is no longer in a saline state, and consequently becomes indissoluble in water like pure earths.

Alkali dissolved in the smallest possible quantity of water, forms a liquor less fluid, more thick, and unctuous than pure water, and which passes with more difficulty through the filter, from the quantity of saline matter with which the water is charged. When it is touched and rubbed betwixt the fingers, it appears to have a fat and oily nature; which proceeds from the greasy particles of the skin dissolved by it. These properties have occasioned it to be called, but improperly, an *oil*, by ancient chemists. *See* OIL *of* TARTAR. It ought to be called the *Liquor of alkaline salt*.

Dry fixed alkali, exposed to a moderate fire, that is, a little more than cherry red, sustains its action pretty well, altho' it fuses, and diminishes in quantity. But by a very violent fire, the greatest part of it is dissipated in vapors, or even all of it, if the heat be sufficiently long and intense. It is easy to be convinced of this by observing the pots in which glass is melted in glass-houses. Above these pots a perpetual smoke may be seen, which can proceed only from the fixed alkali which enters into the composition of glass; the other matters which enter into that composition being infinitely more fixed than it.

Fixed alkali is a very powerful solvent. In the dry way, and by help of proper heat, it dissolves all calcareous, vitrifiable, argillaceous, gypseous, and metallic earths; and in certain proportions, and nearly in equal parts, it changes most of these into different kinds of hard, solid, and transparent glasses. *See* GLASS, VITRIFICATION, CRYSTAL-GLASS.

When a third or fourth part only of earth is added to it, they more readily fuse, and unite together: and as the alkali is the prevailing principle in the new compound which results from this union, so its properties also prevail. Hence it renders the earths so dissolved, soluble in water; and in acids, susceptible of attracting the moisture of the air, &c. *See* LIQUOR *of* FLINTS.

The alkali appears to have no action by the humid way upon substances purely earthy; but it has upon quicklime, to which it gives, and from which it receives, very singular alterations. When it is liquid, and treated with this sub-

 stance,

ſtance, it becomes infinitely more cauſtic and more fuſible than it was before. *See* LIXIVIUM *of* SOAP-BOILERS, CAUTERY. *(b)*

Fixed vegetable alkali unites with the vitriolic acid violently and with great effervefcence. The union of theſe two ſaline ſubſtances is very ſtrong and very intimate; and from thence reſults a perfect neutral ſalt, which is *vitriolated tartar*. *See* TARTAR (VITRIOLATED).

With nitrous acid it forms *nitre*, a neutral cryſtallizable ſalt, the properties of which ſee under the word NITRE.

With marine acid, fixed vegetable alkali forms a particular kind of common ſalt, reſembling in many reſpects the natural common ſalt, but differing from it in others, and chiefly in its taſte, which is much leſs agreeable than that of common ſalt. The differences betwixt theſe two ſalts are cauſed by the difference of their alkaline baſes, natural common ſalt having for its baſis a particular kind of fixed alkaline ſalt, which differs conſiderably from the fixed vegetable alkali. The kind of common ſalt formed with this latter alkali and marine acid is called *regenerated common ſalt*, or SALT (FEBRIFUGAL) *of* SYLVIUS. *See* that article.

Fixed vegetable alkali unites alſo very well with vegetable acids, and with them forms different neutral ſalts, according to the nature of theſe acids. With the acid of vinegar, it makes a neutral deliqueſcent ſalt, of a very pungent taſte, called, *regenerated tartar*, or *Terra foliata tartari*; ſee theſe words. With the concrete vegetable acid, or cream of tartar, it forms a neutral cryſtallizable ſalt called *tartariſed tartar*, or *Salt (vegetable)*; which ſee.

Laſty, fixed vegetable alkali unites alſo and forms true neutral ſalts with any ſubſtances, which, though not pure acids, do however act as acids with relation to alkalies. Such is the ſedative ſalt, with which this alkali forms a particular kind of *Borax*. *See* BORAX and SALT (SEDATIVE). Such alſo is arſenic, with which it unites to the point of ſaturation, and forms a very ſingular, neutral, cryſtallizable ſalt, the properties of which were firſt obſerved by M. Macquer, who gave it the name of *neutral arſenical ſalt*. *See* SALT (NEUTRAL ARSENICAL).

Fixed vegetable alkali diſſolves ſulphur in all its ſubſtance; that is, it unites with both the acid and the phlogiſton of which this mineral matter is compoſed. It only diminiſhes the adheſion of theſe two conſtituent parts of ſulphur. This union of alkali with ſulphur may be made in the humid way and in the dry way; but much better in the latter. Hence reſults a particular ſaponaceous body, called *liver of ſulphur*, which is a powerful ſolvent of all metallic ſubſtances. *See* LIVER *of* SULPHUR.

Metallic ſubſtances are capable of being attacked and diſſolved by pure alkali. Some of them, ſuch as iron, and particularly copper, need only to be digeſted in the liquor of alkaline ſalt, to be perfectly diſſolved. Moſt of the others require to be previouſly diſſolved by acids: but by means of this ſolution in acids they become very ſoluble in alkali. For this purpoſe it is neceſſary to pour ſome drops of metallic ſolution into a very ſtrong liquor of alkaline ſalt: at firſt a precipitate is formed, which diſappears when the liquor is agitated; thus the

(b) The cauſticity which alkaline ſalts acquire by being treated with quicklime, is occaſioned by this ſubſtance depriving them of fixable air, to which it has a ſtronger power of combination than they have. *See* AIR (FIXABLE).

acid metallic solution is to be continued to be poured in at different times into the alkaline liquor, till this latter cannot any longer dissolve the precipitate.

All metals are not by this method dissolved with equal facility, and in equal quantities by fixed alkali. The lunar metals, namely, silver, mercury, and lead, are dissolved by it with more difficulty and in less quantity than the solar metals, such as gold, platina, tin, copper, and especially iron. This last metal gives to the alkali while it is dissolving a beautiful saffron color, approaching to red. This solution of iron by alkali was first published by Stahl, and by him called *martial alkaline tincture*. See TINCTURE (MARTIAL ALKALINE) *of* STAHL.

It is proper to observe upon the subject of the solubility of metals in fixed alkali; 1. That in order to its success, it is very necessary that the previous solution of metal in an acid should be very acid, and very far from the point of saturation. In whatever manner the operation is done, it always fails in making the martial alkaline tincture of Stahl, if a very saturated solution of iron in nitrous acid be employed. M. Macquer and Mr. Beaumé have ascertained the necessity of this management, which is not observed by Stahl or any other chemist.

2. Most of these metallic solutions in alkali preserve their limpidity only during a certain time: after which they become turbid, and a deposition is then formed, of the same color as the solution. This deposition is nothing else than a portion of the dissolved metal which separates from the solvent, as happens to several solutions of metals in acids.

3. A very illustrious chemist recommends for the solution of metals in fixed alkali, particularly of gold, silver, mercury, zinc, and bismuth, an alkali phlogisticated and fit to make Prussian blue. But this is the precise way to fail in the operation. This able chemist has been led into error by some of those circumstances, which are but too frequent in chemistry, and against which it is impossible for the most intelligent persons to be always guarded. Some details upon this subject may be seen under the articles BLUE (PRUSSIAN), *and* TINCTURE (MARTIAL ALKALINE) *of* STAHL.

By fusion and by the dry way, fixed alkali dissolves and vitrifies all metallic calxes, or earths deprived of phlogiston; perhaps even it is capable of dissolving the metals uncalcined.

Fixed vegetable alkali unites easily with oils and oily substances, and communicates to them its property of mixing well with water. With them it forms saponaceous compounds, partaking of the properties of oil, and of those of alkaline salt, as has been said under the article of alkali in general. *See* the word SOAP.

As to the origin of fixed vegetable alkali, it is disputed whether it exists ready formed in vegetables previously to their combustion, by which it is obtained, but which in this supposition does only disengage substances which envelope and disguise it; or whether vegetables contain only the materials proper for its formation, which consequently takes place in the act of burning, and whether it be, properly speaking, produced by fire.

There are reasons for and against these two opinions, and they are so strong on both sides, that there are grounds to believe that both of them are true; that

is.

is to ſay, that the fixed alkali obtained after burning a vegetable, did partly exiſt ready formed in that vegetable before it was burnt, and that the other part was produced by the very act of combuſtion.

The proof of the former part of this propoſition is, that from moſt plants neutral ſalts whoſe baſes are fixed vegetable alkali, ſuch as vitriolated tartar and nitre, may be actually obtained without burning. And ſtill more: M. Beaumé, upon a particular examination of the plant called *corona ſolis*, found that this plant when well cultivated furniſhed not only a very conſiderable quantity of perfect nitre, very ſuſceptible of cryſtallization and detonation, the baſe of which conſequently was fixed vegetable alkali, but alſo a large quantity of this alkali, diſengaged from any acid, well diſtinguiſhed, and poſſeſſed of all its properties. An alkali then does exiſt in vegetables previous to burning. It remains to be examined whether this alkali exiſting in plants previous to burning, be truly one of their principles and conſtituent parts, or only a foreign and unneceſſary ſubſtance. What renders the latter opinion probable, is that the quantity of alkali in plants, whether diſengaged or united to an acid in neutral ſalts, is very variable, and that it appears to depend ſolely on culture and on the nature of the ſoil: ſo that it frequently happens, that the ſame plants which contain much alkali when theſe two circumſtances favor its introduction, contain none at all in contrary circumſtances.

As to the ſecond propoſition concerning the origin of fixed vegetable alkali, which is, that a great part of this alkali is produced and combined by the act of combuſtion, it is eſtabliſhed by ſeveral proofs ſeemingly inconteſtable. The obſervation of the circumſtances concurring to the production of alkali by burning, demonſtrates that this alkali is in great meaſure formed by the vegetable acid, which, during the deflagration of vegetables, combines in a particular manner with a portion of their earth and inflammable principle.

The following obſervations will render this truth evident.

1. When vegetables capable of furniſhing aſhes containing much alkali, are decompoſed by other means than combuſtion, ſcarcely any other ſaline matters are obtained from them but fluor acids, or what are properly called eſſential ſalts, which are nothing elſe than concrete acids rendered ſolid by a portion of oil and earth.

2. When vegetables are deprived of a part of their acid by diſtillation, or by extraction of their eſſential ſalts, the quantity of fixed alkali obtained from their aſhes is as much leſs, as the quantity of acid previouſly taken away was greater.

3. The matter of extracts containing almoſt all the acid of the vegetables uſed for that extraction, and the eſſential ſalts of vegetables are, of all vegetable matters, thoſe which furniſh the greateſt quantity of fixed alkali by burning in open air. The concrete acids particularly are changed by this proceſs almoſt entirely into fixed alkali. A ſtriking example of this is ſeen in the combuſtion of tartar, which is one of thoſe concrete acids.

4. Oils and oily concretions, which contain little acid and earth, leave after burning a ſcarcely ſenſible quantity of fixed alkali.

5. Plants which contain a very volatile acid, and thoſe from which no acid is obtained by diſtillation, ſuch as muſtard ſeed, leave alſo in their aſhes but an almoſt inſenſible quantity of fixed alkali.

6. All vegetables, even those which in their natural state furnish ashes containing much fixed alkali, when burnt, after their acid has been altered by a complete putrefaction, leave ashes entirely free from alkali.

We cannot therefore but conclude, after having attended to these facts, that the greatest part of the fixed vegetable alkali is produced from the acids of vegetables.

We ought also, after what has been said on the origin and production of fixed alkali, to perceive the reason, why vegetable matters, which have undergone decoctions or long macerations in much water, as floated wood, leave but little or no alkali in their ashes. The water has dissolved and carried off either the alkali ready formed, or their acids and essential salts, which, as we have seen, are the principal materials of its composition.

Fixed alkali prepared by the incineration of vegetable substances, and by lixiviating and evaporating to dryness, is very far from the degree of purity requisite in exact chemical experiments.

It is almost always altered; 1. By some remaining inflammable principle which could not be entirely consumed during the burning; 2. By a portion of superabundant earth; 3. By the mixture of different saline matters as fixed as itself, which partly or entirely elude the action of the fire. These saline matters are either some neutral salts, which are frequently found in plants; such as vitriolated tartar, Glauber's salt, common salt, and sometimes a little nitre; or a portion of fixed mineral alkali. 4. As iron is diffused in almost all bodies, and particularly in greater or less quantity in the ashes of vegetables, as Mr. Geoffroy has proved; and further, as iron is very soluble by fixed alkali; this saline substance is subject to be altered by mixture with iron.

Fixed alkali is discovered to be phlogisticated, or altered by a superabundance of inflammable matter; 1. By its color not being perfectly white, and by its lixivium or solution in water being more or less yellow, or red instead of being absolutely colorless; 2. By the smell of its lixivium, which is always so much stronger, as it is more phlogisticated; 3. By its degree of causticity, which is always so much less as it retains more superabundant inflammable matter; 4. Lastly, by its property of forming Prussian blue, by precipitating solutions of iron in acids, when it is much phlogisticated. See upon this last article, Blue (Prussian).

There are two methods of purifying fixed alkali thus altered, that is, of depriving it of all the superabundant inflammable matter it contains. The first is by calcination, according to the general rules and with all the attentions necessary to be observed in calcining by fire. *See* Calcination.

The second method of purifying fixed alkali from superabundant inflammable matter consists in applying to it a body on which it cannot act, and which has a stronger affinity than it with this inflammable matter. M. Beaumé first practised this second method. This able observer, having perceived that when he evaporated in silver vessels red and phlogisticated alkaline lixiviums, these vessels were more and more tarnished, till at length the surface of the silver became quite black, and that the lixivium lost its color in proportion as the silver acquired it, carried this experiment as far as possible; and at length, by renewing the surface of the silver contiguous to the alkaline lixivium, he deprived this lixivium of all its color, and rendered it entirely white. This lixivium being then

then evaporated to dryness, furnished an alkali very white, very caustic, and free from all superabundant phlogiston. Besides the practical method of dephlogisticating alkaline salt, which this experiment suggests, it also confirms a truth demonstrated by M. Macquer in his theory of Prussian blue; namely, that metallic substances may be charged with a superabundant quantity of inflammable matter, and that they are capable of taking it from fixed alkali by the humid way. *See* Blue (Prussian).

The second substance which alters fixed alkali is a superabundant earth. As this earthy substance is not soluble in water when alone, and as it has but a weak adhesion to the alkali, it may be easily separated by drying it once or twice by solutions and filtrations. But this purification must not be carried too far, because the alkali itself is capable of decomposition by this method, in detaching itself at every drying or calcination from a part of its earthy principle.

As to the saline matters which by their mixture alter the purity of the fixed alkali, they can be separated by no chemical process but by crystallization. This method is founded on the incapacity of the alkaline salt to crystalize, and on its property of decomposing and of converting into crystallizable salts, all uncrystallizable and deliquescent salts with which it may be mixed. It is then necessary to evaporate to the convenient point, the alkaline liquor from which these foreign salts are to be separated, and to let it cool at several different times to favor the crystallization of those salts which are best crystallized in the cold, or to continue the evaporation for those salts which, like common salt, can only be crystallized by this method. *See* Crystallization. But it is manifest, that this method, however carefully performed, is incapable of procuring a perfect separation of all the extraneous salts from the alkali; since while this continues fluid, it always remains mixed with a small quantity of crystallizable salts, which are dissolved by part of the same water which keeps the alkali fluid; and that the separation by crystallization cannot take place but when all is evaporated to dryness. It is then impossible to separate completely from the alkaline salt, the last small portions of extraneous salts with which it was mixed. Notwithstanding this, the degree of purity to which the alkaline salt may be brought by this method is considerable, and sufficient for most of the operations of the arts, and even for many operations in chemistry.

It is still more difficult to purify the alkali from iron. No practical method is known for this purpose. When therefore a very pure alkali is required, it is proper to choose such substances as furnish a salt the least impure. For in this respect there is a great difference betwixt the substances from which it may be obtained, as will appear when we enumerate summarily the several alkalies most frequently used.

Fixed alkali being of great use, and much employed in arts, as it is the basis of soap and leys, and much used in dying, making of glass and saltpetre, is procured from matters which furnish a great deal of it, and at a small expence.

The most common alkali, and at the same time the least pure, is that of the ashes of common hearths. These ashes are employed for lixiviums, in the manufacture of salt-petre, and in glass houses where common bottle-glass is made.

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In the Northern countries, where wood is plentiful, it is burnt on purpose, as well as many plants, to procure from their ashes a strong but very impure alkali, called *Pot-ash*. This alkali is always much phlogisticated, and contains many of the saline matters above-mentioned. Pot-ash is employed for the purposes related. It is also used by dyers in some of their operations. Pot-ash may be purified so far as to become a very good alkali by the methods mentioned. (*i*)

The dregs and leys of wine being dried and burnt, leave ashes abounding in alkaline salt, called in French, *cendre gravelée*. This alkali is not only in great quantity in these ashes, but likewise when the matters furnishing it are properly and carefully burnt, it is the purest of all those which are in commerce. If

(*i*) The great consumption of pot-ash renders it a matter of importance. We shall therefore describe the methods of preparing it.

In some parts of Germany it is prepared from the same wood of which charcoal is made. A number of tubes, made of plate iron, or of copper or brass, are so disposed in the pile of wood intended to be burnt into charcoal, that the water, acid, and oil, which are obtained in ordinary distillations, shall, when separated from the wood by fire, pass through these tubes into buckets placed to receive these liquors. The oil is then to be separated from the acid liquor, which is then to be boiled in copper or iron vessels, and the residuum dried and calcined. By this calcination, the acid salt is alkalized. This method, and the preparation of salt of tartar by calcining tartar, shew that vegetable alkali is produced by conversion of an acid to an alkali. How is this conversion effected?

The most common method of making pot-ash, is by burning large piles of wood, lixiviating the ashes by boiling in copper vessels, decanting the lixivium when clear, and boiling in other copper vessels till the liquor be evaporated and a reddish solid salt obtained, called *black pot-ash*, which by calcination in ovens with a heat not intense enough to fuse it, is dephlogisticated and rendered white. If any of it has been fused, it will have a greenish blue color.

Another method of preparing pot-ash, and which may be conveniently used in a large manufactory of it, is described by Kunckel. The ashes of wood are put into a large tub, near the bottom of which is inserted a cock; and to prevent the ashes from filling up the cock, the bottom is covered with straw and pieces of small wood. Water is to be poured on the ashes, and is the next day to be let off through the cock into another vessel. The ashes may be again elixated with more water till all the salt be dissolved. The weaker leys are to be poured on fresh parcels of ashes till they can receive no more salt. The ley is then to be evaporated in an iron pan, and the brown salt is to be dephlogisticated by calcination in a furnace or oven with a heat not intense enough to fuse it.—Some persons soak straw in the ley obtained by lixiviating wood-ashes with water, and by drying and burning this straw they obtain a salt without the trouble of boiling the ley. The alkaline salt called *pearl-ash* has a whitish pearl color, and is almost entirely soluble in water. The Russia pot-ash is dark-colored, hard, not easily deliquescible, and contains (as Dr. Lewis says) more than half its weight of an earth unsoluble in water. Scheffer, in the Swedish Memoirs for the Year 1759, says, that from 100lb. of Russian pot-ash he obtained 92½ lb. of alkaline salt, and 7½ lb. of neutral salts. Dr. Home found that Russia pot-ash contained a considerable quantity of quicklime. From experiments made by Brandt (*Memoires Suedoises* 1749), and from the preference given to it by soap-boilers, it appears to be more caustic, and more powerfully to dissolve oils, than purer pot-ash rendered caustic by quicklime. Russian pot-ash is said to be prepared by burning wood with a close smothering heat; making a ley from the coarser part of the ashes, and moistening therewith the finer part into the consistence of a paste, stratifying this paste with some of the more inflammable kinds of wood, and setting the pile on fire. The neutral salts found in pot-ash are chiefly vitriolated tartar, sea-salt, with which latter salt pot-ash is frequently adulterated to increase its weight.

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it contains iron, it is in an insensible quantity, and it is naturally free from mixture of extraneous salts: therefore dyers and other manufacturers whose operations require a pure alkali, prefer these to any other alkaline ashes.

Fixed Alkali *of* Tartar.

TARTAR, which is nothing but the concrete acid or essential salt of wine, being properly burnt, is almost entirely changed into an alkaline salt, very strong, and the purest of all; and which therefore has been reasonably preferred by chemists to any other. It is called the *Alkaline Salt of Tartar*, or simply *Salt of Tartar*. Hence this name has become in some measure synonimous with that of alkali.

Salt of tartar is made by wrapping up in wet brown paper the tartar intended to be burnt, and placing these parcels so wrapped up in a furnace, by beds or strata, together with strata of charcoal, alternately; and by setting fire to the whole, and continuing the fire till no more blackening smoak rises.

As tartar is almost entirely changed into alkaline salt, it preserves after incineration a certain consistence, and retains the form it had before burning; which makes it easy to collect it properly. But too great heat must be prevented in burning tartar, otherwise the alkali would melt and flow to the bottom of the furnace, where it would mix with the impurities of the charcoal. To avoid this inconvenience a furnace entirely open may be employed, in which the charcoal may burn freely, but without any strong current of air to render the heat too intense. On the other side, as fire is generally more intense in great than in small operations, where proportionable quantities of combustible matters are used, when much tartar is to be burnt, it is proper to diminish the quantity of charcoal, to prevent too great heat, and the consequent fusion of the alkali.

When tartar is sufficiently burnt, a lixivium must be made from it till the water poured on it receives no more taste. It must then be filtered, evaporated, dried and calcined, according to the directions given to obtain the alkali of tartar in its greatest purity.

Fixed Alkali *of* Nitre.

THE basis of nitre being a fixed alkaline salt of the nature of the vegetable alkali, and the acid of this salt being capable of decomposition and total destruction by deflagration, we may obtain separately its alkali, called *alkalised or fixed nitre*, by burning or detonating it with combustible matters. As this combustion is very rapid, and as it is alkalised almost instantaneously by detonation, it has been also called extemporaneous alkali.

Those vegetable substances only which contain an acid yield an alkaline salt by incineration. From mustard and other vegetables which yield a volatile alkali and no acid by distillation, no fixed alkali can be obtained.

The ashes of firs, pines, and all trees which contain much resin and essential oil, yield a small quantity only of fixed alkali by elixation. The cause of this seems to be, that the acid of these trees is very volatile, and together with a volatile inflammable matter forms the essential oils and resins. *See* Resins.

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The matters moſt convenient and moſt frequently uſed for the deflagration of nitre are charcoal and tartar. The alkali made by deflagration of nitre with charcoal is called NITRE *fixed by* CHARCOAL. *See* this article for the method requiſite.

Nitre and tartar burnt together produce a very ſtrong alkali, which is a mixture of the alkali of nitre and of the alkali of tartar, both which are entirely of the ſame nature. They are confounded together by the name NITRE *fixed by* TARTAR. *See* that article, and FLUX (WHITE).

Theſe alkalies of nitre, when well prepared, are very pure, and fit for the niceſt operations in chemiſtry.

All theſe ſeveral kinds of alkali, when perfectly purified, have entirely the ſame properties, and ought to be regarded only as one and the ſame alkali, which ought to be called *Fixed Vegetable Alkali*. The purification above-mentioned of this alkali is attended with conſiderable difficulties in practice. The chief of theſe difficulties is in the evaporation and drying of the alkaline lixiviums; and this relates to the veſſels employed in theſe operations. Veſſels made with the imperfect metals are unfit, becauſe they are liable to the action of the alkaline ſalt. Silver veſſels are the fitteſt of all for this purpoſe: but it is not very certain that this metal is incapable of being acted upon by alkali.

Glazed earthen veſſels, ſuch as common pottery-ware, cannot be employed, becauſe they are not, and cannot be ſufficiently baked. The alkaline lixivium paſſes through them as eaſily as through a filter. If veſſels not metallic are to be uſed, they ought to be of glaſs or porcelaine, or made of pure clay, and baked in a violent fire, ſuch as that kind of pottery called ſtone-ware. Theſe veſſels perfectly reſiſt the action of alkalies, but they are very liable to be cracked by heat.

Well-prepared fixed alkali ought to be preſerved, either dry or fluid, in cryſtal-glaſs bottles, with glaſs ſtoppers. When the fluid alkali is uſed, it muſt be gently decanted from the ſediment depoſited at the bottom of the bottles.

XXXIII. ALKALI (MINERAL *or* FOSSIL), or ALKALI (MARINE). This is a ſaline, alkaline, fixed ſubſtance, ſerving as a baſis to the acid of common ſalt, and forming with it the native neutral ſalt which is diſſolved in large quantities in the ſea, and known by the names *Common Salt* and *Sea-Salt*. As this ſalt is a natural production, and belongs neither to the vegetable nor animal kingdoms, it has been ranged amongſt minerals, and therefore called mineral alkali: notwithſtanding that a conſiderable quantity of this ſalt may be obtained from the aſhes of ſeveral vegetables. But its origin is always the ſame, and it is not to be conſidered a vegetable ſubſtance; for we ſhall ſee that mineral alkali obtained from vegetables, proceeds always from common ſalt contained in theſe vegetables. After we have mentioned the properties of this alkali, we ſhall deſcribe the method of procuring it in its greateſt purity.

Fixed mineral alkali has eſſentially and fundamentally all the properties of fixed vegetable alkali. It has the ſame taſte and the ſame fixity. It diſſolves all the ſame ſubſtances, and exhibits with them very ſimilar phenomena. It melts and vitrifies all earths, and is altered by quicklime in the ſame manner. It combines

bines with all acids to the point of ſaturation, and with them forms neutral ſalts. It has the ſame action as fixed vegetable alkali on metallic ſubſtances, and forms ſoaps with oils and oily matters; therefore, in order to have a juſt idea of the alkaline properties of this ſaline ſubſtance, it is very neceſſary to read exactly and entirely what has been ſaid under the articles ALKALI and ALKALI (FIXED VEGETABLE). But it alſo differs very conſiderably from fixed vegetable alkali by ſeveral properties peculiar to it; and it is upon theſe properties we are chiefly to inſiſt in this article.

Fixed mineral alkali, which we here ſuppoſe to be in its greateſt purity, differs from fixed vegetable alkali.

1. By its taſte, which is a little leſs fiery and corroſive: but this difference is very ſlight.

2. When dried, it does not attract the moiſture of the air ſufficiently to form a liquid, as fixed vegetable alkali does.

3. If it be diſſolved in water, when it is dry and calcined, it does not heat the water nearly ſo much.

4. When diſſolved in water, and its ſolution evaporated and cooled, it coagulates into cryſtals, preciſely as neutral ſalts do. In this it differs conſiderably from fixed vegetable alkali, which is abſolutely deliqueſcent, and not cryſtallizable. (*k*)

The cryſtals of mineral alkali contain much water, and have but little adheſion to this water; for moſt of it is diſſipated by expoſure to open air. By this diſſipation of water the cryſtals loſe their form and tranſparency, which were owing, as of all neutral ſalts, to the water contained. *See* CRYSTALLIZATION.

Cryſtals of mineral alkali thus deprived of their water, fall into a white powder: therefore, to preſerve them, they muſt be put into bottles as ſoon as they are drained.

The differences related betwixt the vegetable and mineral alkalis ſhow that this latter poſſeſſes ſaline properties in a leſs eminent degree; which probably proceeds from the abundancy of its earthy principle.

5. Fixed mineral alkali diſſolves by fuſion, and vitrifies all earths like the vegetable alkali. But it has been obſerved, that it vitrifies earths better, and renders the glaſs more ſolid and durable. Probably this proceeds from the greater fixity of the mineral alkali, from its containing an earth leſs combined, and alſo from its want of the deliqueſcent quality.

6. With vitriolic acid, mineral alkali forms a neutral cryſtallizable ſalt called *Glauber's ſalt*, which differs from vitriolated tartar in the following circumſtances. 1. Its cryſtals are of a different figure and larger ſize. 2. They contain more water. 3. They are more ſoluble in water. 4. Their adheſion to the water of their cryſtallization is leſs, inſomuch that this ſalt by expoſure to air loſes its water, and conſequently its form and tranſparency, and becomes a white powder, as the mineral alkali does alſo when expoſed to air. *See* SALT *of* GLAUBER. As the ſame acid is in Glauber's ſalt and in vitriolated tartar, the differences above related muſt proceed from their alkaline baſes: therefore all the properties which diſtinguiſh Glauber's ſalt from vitriolated tartar are to be conſidered as the differences

(*k*) We have obſerved in a note upon the former article, that fixed vegetable alkali is cryſtallizable by expoſure to fixable air.

ferences betwixt the vegetable and mineral alkalis. The same observation may be applied to all combinations of mineral alkali with the other acids, of which we are now going to speak.

7. With nitrous acid, mineral alkali forms a particular kind of nitre, susceptible of detonation and of crystallization; but it differs from ordinary nitre, or that which has for its base fixed vegetable alkali, in the figure of its crystals, which, instead of being like long needles, are solids, each of which has six rhomboidal faces; that is to say, two angles of each face are acute, and the other two obtuse. This figure, which is somewhat similar to that of a cube, has occasioned this salt to be called *cubic* or *quadrangular nitre*. This figure is caused by the mineral alkali. *See* NITRE (QUADRANGULAR).

8. With marine acid, mineral alkali forms common salt, the crystals of which are perfect cubes. This salt differs from the neutral salt formed by the combination of the same acid with vegetable alkali chiefly by its taste, which is infinitely more agreeable. *See* SALT (COMMON).

9. Mineral alkali forms with the acid of vinegar a neutral salt entirely different from the *terra foliata tartari*, which is deliquescent and not crystallizable, while the former crystallizes well, and does not attract the moisture of the air. This salt has no particular name. *See* SALT (NEUTRAL) *Composed of the* ACID *of* VINEGAR *and of* MINERAL ALKALI.

10. With the concrete tartareous acid, mineral alkali forms a neutral crystallizable salt, differing from that made with the same acid and vegetable alkali, or *vegetable salt*, by the figure of its crystals, which are also much larger and finer. *See* SALT VEGETABLE.

11. Mineral alkali very well dissolves oils and oily matters, and with them forms saponaceous compounds, as the vegetable alkali does. But soaps made with this latter alkali remain soft, and do not acquire such consistency and hardness as those made with mineral alkali. This difference is certainly caused by the property which mineral alkali has of crystallizing. *See* SOAP. *(l)*

It is probable, that if we were to examine attentively the combinations of marine alkali with sulphur and metallic substances, sensible differences might be discovered from similar combinations made with vegetable alkali. The discovery of these differences could not fail to throw new light upon the nature of this alkali. But I do not believe that sufficient experiments have been made on this subject. *(m)*

Several celebrated chemists have, however, made considerable researches into the nature of marine alkali. The person who has done most in this way is M. Duhamel de Monceau, a member of the Academy of Sciences. He has published

(l) The difference mentioned in the text does certainly not proceed from the crystallizing quality of mineral alkali; for this salt probably proceeds from that property of mineral alkali by which it has a weaker power of combination with water than vegetable al-

air, renders it caustic, and incapable of forming crystals. *See* AIR (FIXABLE). The greater hardness of soaps made with mineral alkali than of those made with vegetable alkali, vegetable alkalies; namely, that platina may be precipitated from its solution in aqua regia by the latter, but not by the former.

in ſeveral memoirs, a detail of many experiments made to decompoſe common ſalt, that he might obtain the alkaline baſis ſingle and pure, for the purpoſe of examining its properties. Common ſalt not being capable of decompoſition merely by the action of fire, and without the application of another ſubſtance, it was neceſſary to find ſome ſubſtance which could carry off the marine acid, without combining itſelf with the alkaline baſis. As phlogiſton produces this effect very well on thoſe neutral ſalts which are compoſed of a fixed alkali and vitriolic or nitrous acids, it was natural to try the ſeparation of the marine acid by the ſame intermediate ſubſtance. This M. Duhamel did, but without ſucceſs; altho' in his experiment he employed every reſource of the moſt enlightened chemiſtry. The ſame thing happened to Mr. Margraaf, who tried without ſucceſs to combine marine acid with phlogiſton, in order to produce phoſphorus. It appears, then, that art does not yet furniſh any method of decompoſing common ſalt by phlogiſton.

It is nevertheleſs probable that this decompoſition is not impoſſible, and that it even takes place every day in the combuſtion of maritime plants of the *kali* kind, all of which contain ſea-ſalt, and when burnt, furniſh a conſiderable quantity of cryſtallizable alkali, which being combined with the vitriolic and nitrous acids forms Glauber's ſalt and cubic nitre, entirely ſimilar to thoſe formed from the decompoſition of common ſalt by theſe two acids. It is very probable that this cryſtallizable alkali obtained from the aſhes of maritime plants, proceeds from a portion of ſea-ſalt contained naturally in theſe plants, a part of which is decompoſed by the burning; for it is certain that no trace of a diſengaged alkali can be obſerved in theſe plants previouſly to their incineration.

However that be, it is certain that this cryſtallizable alkali obtained from the aſhes of maritime plants, is entirely of the ſame nature as the natural alkaline baſis of ſea-ſalt. This is a truth which no chemiſt queſtions. But diſputes have ariſen concerning the ſaline alkaline nature of this ſubſtance.

The inquiries of M. Duhamel had proved to him, that it had the principal marks of a ſaline alkali; he concluded that it really was ſuch. On the contrary, the celebrated Mr. Pott, who has alſo made many experiments on this matter, has always maintained that it was only a pure earth, without the properties of an alkaline ſalt. This diverſity of ſentiments has occaſioned a literary diſcuſſion betwixt theſe two learned gentlemen, of that kind which always turns out to the advantage of ſcience; as it has occaſioned a great number of beautiful experiments, which greatly illuſtrate this matter

The ſtrongeſt proof brought by Mr. Pott in ſupport of his opinion may be found in the eclairciſſements given to the ſequel of the French tranſlation of his Lithogeognoſia. Mr. Pott ſays, "that by a fixed or volatile alkali an inſipid and "perfectly inſoluble earth may be precipitated from the mother water of ſea-ſalt. "This earth united to the vitriolic acid forms a Glauber's ſalt perfectly ſimilar to "that prepared from ſea-ſalt. This Glauber's ſalt produces with charcoal a ſaline alkaline body, which is not precipitable by fixed vegetable alkali; which "alſo happens preciſely to Glauber's ſalt prepared with ſea-ſalt. This alkaline "ſalt is not produced by the vitriolic acid, nor by the charcoal, but principally "from this ſaline earth, which for that reaſon may be called an *alkaline earth*, "nearly approaching a ſaline ſtate, and which is capable of taking from acids a

" proper portion of their most ſubtle parts, by combination with which it becomes a genuine alkali."

As to what remains, it appears that, after the properties of fixed alkaline ſalts and of the baſis of ſea-ſalt have been eſtabliſhed, it is eaſy to decide the queſtion. Nothing can be ſaid more ſenſibly on this ſubject than the following quotation from the learned and judicious tranſlator of Mr. Pott's Lithogeognoſia. " This " queſtion is now reduced to a diſpute about words, ſince Mr. Duhamel agrees " with Mr. Pott that the baſis of ſea-ſalt differs from the fixed alkali of nitre and " others ſimilar; and that Mr. Pott agrees with Mr. Duhamel, that it differs " from common abſorbent earths. But hitherto it ſeems that Mr. Duhamel's " expreſſion is more juſt and conformable to the definition of ſaline ſubſtances."

From all this we ought to conclude, that the baſis of ſea-ſalt is neither a pure earth, nor an alkali ſimilar to that obtained from vegetables, but a ſaline alkaline ſubſtance of a peculiar nature; and if conjectures may be allowed on the nature of this alkali, I ſhould be inclined to believe, that it differs from the vegetable alkali, either becauſe a larger quantity of earth enters into its compoſition, or becauſe its earthy principle is united to it more intimately.

Further, it appears that the baſis of common ſalt is truly of a ſaline nature, from its ſucceſsful and even advantageous application to all the ſame purpoſes in the arts as fixed vegetable alkali, as has been ſaid above.

The only practical method of procuring this alkali in great quantities is by the incineration of maritime plants. Theſe aſhes contain much mineral alkali, when the plants happen to grow in a favorable ſoil and climate, and the mineral alkali is found to be more or leſs pure, according to the nature of the plants and of the ſoil. Theſe aſhes are generally known in commerce by the name *Soda*. This ſoda is employed in arts without purification; hence there is obſerved a great difference betwixt different ſodas, ſome of which are much better than others. *(n)*

As the chemical affinities and the medicinal virtues of the mineral and of the vegetable alkalis are the ſame, we proceed to mention what is moſt material on theſe ſubjects.

The *affinities of fixed alkali*, according to Mr. Geoffroy's table, are in the following order: vitriolic acid, nitrous acid, marine acid, vinegar, ſulphur.

Mr. Gellert's table is more extenſive, and is as follows: Phlogiſton, vitriolic acid, nitrous acid, marine acid, vegetable acid, zinc, iron, copper, lead, tin, regulus of antimony, regulus of cobalt, arſenic and biſmuth. Gold and ſilver are marked in this table as indiſſoluble by fixed alkali.

As fixed alkalis are the greateſt abſorbents of acids, they are proper for all thoſe maladies deſcribed by Boerhaave as proceeding from a ſpontaneous acid.

(n) Mineral alkali is found lying upon the ground in the iſland of Tenerif, and in many other countries. The Spaniſh aſhes called *bariglia*, or *ſoda*, are produced by burning kali, varech, or fucus marinus, alga marina, and other maritime plants, previouſly dried, in pits dug in the ground. The fire employed is ſo violent as to fuſe the aſhes into one large and hard bluiſh maſs. From theſe plants Henckel obtained, by boiling in water, evaporating and cryſtallizing, a conſiderable quantity of marine ſalt. Stahl, Gellert, and other authors, prefer this ſalt to vegetable alkali, for the formation of glaſs, durable, and not attackable by acids. But Kunckel obſerves, that the impurities mixed with common ſoda, or bariglia, give a bluiſh color to glaſs, and render it liable to crack, when cooled. Stahl obſerves, that the ſame effect is produced by common pot-aſh. The mineral alkali, as has been obſerved in the text, makes a finer, harder ſoap than vegetable alkali. It is alſo ſaid to be more effectual in the reduction of metallic calxes.

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They are even preferable to absorbent earths, (although these latter are more frequently used) in cases where, notwithstanding signs of acidity, a putrescent disposition is apprehended; which is not at all impossible, because they are, like all saline matters, antiseptic, according to the observations of Dr. Pringle. But if the putridity was advanced to alkalescency, which is very rare, they would be very hurtful, because they would encrease this alkaline acrimony.

It must not be supposed that fixed alkalis taken internally enter the blood-vessels with their alkaline qualities. If that happened, they would be true poisons, as acids are; since they quickly kill animals into whose veins they are injected.

The human constitution, which cannot suffer the presence of any sensible and disengaged acids or alkalis, at least to a certain degree, in our fluids, acts upon alkalis taken internally by combining them in digestion with the acids of aliments, or with their oily parts, forming soaps, in which conditions only they can arrive at the blood.

Pure alkalis ought never to be prescribed but in small doses, as from half a grain to two grains, when they are incorporated with solid medicines and in small bulk; but they may be given from one to six grains, if they be diluted, on account of their causticity, in a pint of some watery vehicle. These saline substances are dissolving, aperitive, and lithontriptic. They are not much employed for these qualities; but are principally used to correct resinous purgatives, which they do very well, by giving to these medicines a saponaceous quality. Externally applied, these alkalis are resolvent, discutient, and caustic. (o)

XXXIV. ALKALI (VOLATILE). Volatile alkali is a saline substance procured by decomposition, from all animal, and from some vegetable substances, and by putrefaction from all these matters. (p)

This saline substance is called *alkali*, because in fact it has all the general properties of saline alkalis, as the sharp, caustic and burning taste, the property of

(o) Dr. Smith, in a treatise *de motu musculari*, mentions an extraordinary fact which he affirms to have ascertained by repeated experiments, namely, that of the many substances which he mentions, acid, alkaline, and corrosive, mineral alkali and compounds formed of it, were alone capable of stimulating or irritating the muscles of frogs, by immediate application to them, which were exposed for the sake of making these experiments.

(p) The plants from which volatile alkali is obtainable by distillation are chiefly of the cruciform kind. This salt is obtained by distilling all kinds of clays, (as Brandt says) many calcareous earths, chiefly that kind called Lapis suillus, and some mineral waters. Sal ammoniac, which contains volatile alkali, is sublimed in volcanos. Sal ammoniac may be produced from soots of burning vegetable or animal substances, and even of mineral coal. Authors mention various methods by which volatile alkali may be produced. As a knowledge of these may assist us to form a theory concerning this saline substance, we shall relate some of them. Volatile alkali may be produced by heat, 1. From a mixture of quicklime with vitriol, or with alum, or with tartar. *Pott.* 2. From a mixture of any essential oil with vitriolic acid and fixed alkali. *Id.* 3. From nitre detonating with charcoal. *Id.* 4. From a combination of marine acid with quicklime. *Id.* 5. From magnesia alba by distillation. *Dr. Black.* 6. From tartar. *Id.* 7. From deliquiated salt of tartar poured on white salt of vinegar. *German Ephemerides, Pott, Ludovici, and Hoffman.* 9. From sea-salt combined with putrefying substances. *Pott.* 10. From sea-salt distilled with charcoal. *Id.* 11. From sea-salt distilled with quicklime. *Id.* 12. From salt of Sylvius distilled with fixed alkali. *Beck and Peterman.* 13. From sea-salt distilled with clay. *Brandt.* 14. From rust of iron distilled. *Bourdelin.*

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tinging violets with a green color; of combining with acids to the point of saturation, and forming with them different neutral salts, most of which are crystallizable; of separating all earthy and metallic matters from their union with acids; lastly, of dissolving by the humid way, almost all substances soluble by other alkalis.

This alkali is called *volatile*, because in fact it is very much so. Its volatility is owing to a portion of attenuated, very subtle, and very volatile oil, which enters into its composition as one of its principles, as is proved by its distinguishing properties.

Volatile alkali differs according to the substances whence it is procured, and according to the manner of obtaining it. These differences proceed from some principles superabundant and extraneous; particularly, several oils from which it is not at first exactly depurated. But all volatile alkalis, however obtained, and from whatever substances, may be so purified by the method which shall be soon described, that no difference remains amongst them; and hence we ought to conclude of this substance, as well as we did of the various kinds of fixed alkali, that it is single, identical, and always similar to itself, when sufficiently purified.

Pure volatile alkali differs from fixed alkali, first, by its greater volatility, which is so great that it may be entirely sublimed or dissipated by a heat much less than the heat of boiling water; by its smell, which is only an effect of its volatility: the smell of this salt is strong, very penetrating, and so pungent, that it cannot be endured above an instant, without suffocation or fainting; its vapor, excites a cough, and brings tears into the eyes. It is this salt which occasions the pungent smell observed in necessary-houses at changes of weather.

This alkali differs also from the fixed by its less force; hence fixed alkalis are capable of decomposing all those salts whose bases are volatile alkali, of separating it from these salts, and of setting it at liberty.

Volatile alkali unites perfectly with water, to which it has even a strong affinity, and with it retains fluidity: it is then called volatile alkaline spirit. When it contains no superabundant water, it is in a concrete form, and is crystallized, in which it differs from fixed vegetable alkali. *(q)*

All acids unite and effervesce with volatile alkali to the point of saturation, forming neutral salts generally called *ammoniacal salts*.

Ammoniacal salts have an infinitely stronger and more pungent taste than salts whose bases are fixed alkali, because volatile alkali unites with acids less intimately. These neutral salts are semi-volatile; that is, they may be sublimed by a sufficiently strong heat; and this property they owe to the volatility of their alkaline basis.

The ammoniacal salt which volatile alkali forms with vitriolic acid is crystallizable, an[illegible] is called *vitriolic ammoniacal salt*, or *secret ammoniacal salt of Glauber*, from the [illegible]me of the chemist who discovered it. *See these words.*

The kind of nitre formed by volatile alkali and nitrous acid is also crystallizable, and has the peculiar property of detonating alone, when heated sufficiently, without addition of any matter containing phlogiston, as is necessary for

(q) Volatile alkali, by combination with fixable air, is crystallizable; uncombined, it can[illegible] [illegible]e obtained in a solid state.

the detonation of ordinary nitre. This phenomenon proves the existence of the inflammable principle in volatile alkali. This nitre, whose basis is volatile alkali, is called *ammoniacal nitre*, or *nitrous ammoniacal salt*. *See these words*.

With marine acid, volatile alkali forms also a neutral crystallizable salt, called *Sal Ammoniac*. This is the most used, and first known of the ammoniacal salts, and from which the name has been derived to the others. *See* SAL AMMONIAC.

Volatile alkali may be combined with sulphur, with which it forms a kind of volatile liver of sulphur, the preparation of which is given by Hoffman. *See* LIVER *of* SULPHUR.

Most metallic matters are attacked, and more or less dissolved by volatile alkali; but copper is of all metals the most easily and copiously dissolved by it. To dissolve this metal nothing more is requisite than to digest its filings in liquid volatile alkali. The solution acquires a beautiful blue color.

This solution exhibits a curious and interesting phenomenon, which is, that if the bottle containing it be well corked, the blue color grows fainter, and at length entirely disappears, so that the liquor becomes colorless like water. But if the same bottle be then uncorked, the upper part of the solution from its contact with the external air resumes its color, and this color is gradually communicated to the rest of the liquor. Thus may this blue color be made to appear and disappear alternately, as often as is required, by corking and uncorking the bottle.

Other metallic matters are not nearly so easily attacked by volatile alkali as copper is. These solutions have even not been much examined.

When metals are previously dissolved and divided by acids, they are then infinitely more susceptible of solution by volatile alkali. For this purpose it is sufficient to pour into some strong alkaline spirit some drops of metallic solution. At first a precipitate is formed, which soon disappears upon agitating the liquor, and is redissolved by the volatile alkali. That this experiment should succeed, it is necessary that the metallic solution should have a considerable excess of acid; that is, that the acid should not be nearly saturated with the metal. By this method, copper and mercury are dissolved in greater quantity than other metals.

In whatever manner the copper be dissolved by this salt, it always communicates a blue color, very beautiful and deep. This property renders the alkaline spirit a proof liquor to discover copper, and render it sensible when it could not, from the smallness of its quantity, be perceptible by other methods. Thus a little volatile alkali may be poured into any mineral water, containing too small a quantity of copper to be otherwise perceptible. The blue color which this water assumes discovers the presence of copper.

Volatile alkali, added gradually to a metallic solution, seizes the acid of the solution, and precipitates the metal. The most singular metallic precipitate made by volatile alkali is that of gold previously dissolved in aqua regia. This precipitate is of a yellow color, and is one fourth part heavier than the gold employed. (*r*) When heated to a certain degree, it detonates and fulminates with a most terrible explosion. It is called *fulminating gold*. *See* GOLD (FULMINATING).

(*r*) Dr. Black, in his Essay upon Magnesia, attributes the encrease of weight which metallic precipitates gain, to adhering fixable air, which they receive from the precipitating alkalis. To this adhering air he also attributes the fulminating property of the precipitate called *Fulminating Gold*.

Mercure

Mercury diſſolved in ſpirit of nitre, and precipitated by volatile alkali, is of a ſlate color. This color proceeds from the inflammable matter of the volatile alkali. The other metallic precipitates made by volatile alkali have nothing ſingular: none of them fulminates like the precipitate of gold; even that of platina does not, tho' this metal poſſeſſes ſo many of the properties of gold. (s)

Volatile alkali, as well as fixed, acts upon oils, and forms with them different ſaponaceous compounds; hence this ſalt may be employed to ſcour and clean from greaſe; and lixiviums made of quicklime and urine which contain much volatile alkali, are uſed in ſome arts. This alkali is nevertheleſs leſs eaſily united with oils than fixed alkali is, and particular management is neceſſary to bring it to a ſaponaceous ſtate. *See* SPIRIT (VOLATILE AROMATIC OILY); and EAU DE LUCE. Theſe are the principal ſaponaceous compounds made with volatile alkali.

Volatile alkali, when firſt ſeparated from animal and vegetable matters, is, as we before obſerved, very impure. It is particularly depraved by much empyreumatic oil, which is united with it into a ſtate perfectly ſaponaceous, and which it renders ſoluble in water. It may be ſeparated from this ſuperfluous oil by diſtilling it with a very gentle fire, either alone, or mixing with matters capable of abſorbing and retaining the oil, as fixed alkalis and abſorbent earths are. But the moſt efficacious method of purifying it is, to reduce it to ſal ammoniac, and then to decompoſe this ſalt, by any of the proper mediums for the diſengagement of the volatile alkali. By this method it is obtained in its greateſt purity; becauſe, in its combination with the acid, it perfectly ſeparates itſelf from all extraneous matter. *See* SAL AMMONIAC, *for the purification of volatile alkali, and for ſeveral of its eſſential properties.* (t)

The affinities of volatile alkali, according to Mr. Geoffroy's table, are, vitriolic acid, nitrous acid, and marine acid. According to Mr. Gellert's table they are, phlogiſton; vitriolic, nitrous, and marine acids; vinegar; zinc; iron; copper; biſmuth; mercury; ſilver; and gold.

(s) From Mr Margraaf's Experiments, publiſhed in the Berlin Memoirs for the year 1745, we find that gold, ſilver, biſmuth, zinc, and copper, diſſolved in their proper acid ſolvents, may be firſt precipitated from theſe, and afterwards rediſſolved by volatile alkali; that theſe metals precipitated by fixed alkalis may be again diſſolved by volatile alkali; and that mercury, lead, and tin, were not diſſolved by volatile alkali applied in the ſame manner. Brandt ſays, that volatile alkali occaſions a coagulation of a ſolution of iron in nitrous acid, which is ſoon rediſſolved; and that the ſame alkali precipitates iron from vitriolic acid. He alſo ſays, that regulus of cobalt cannot be precipitated from nitrous acid, nor arſenic from aqua regia, by volatile alkali. Volatile alkali has no effect upon any metal not previouſly diſſolved by acids, excepting copper, iron, and lead; the firſt of which it diſſolves perfectly, a very ſmall quantity of the ſecond, and the third is very ſlowly changed by it into a kind of mucilage. See POTT *ſur la Diſſolution des Corps.*

(t) To the properties above-mentioned of volatile alkali, we may add, 1. That pure or cauſtic volatile alkali, that is, uncombined with fixable air, or the ſpirit of ſal ammoniac obtained by quicklime, is ſoluble in ſpirit of wine, and that mild volatile alkali is not ſoluble in that ſpirit; hence if a ſtrong ſolution of mild volatile alkaline ſalt be added to ſpirit of wine, the water of the ſolution will combine with the ſpirit, and the ſalt will be precipitated, forming what is called *Offa Helmontii*. 2. Mild volatile alkaline ſalt requires four times its quantity of water to diſſolve it: cauſtic volatile alkali, as we have already obſerved, is always combined with water. 3. Volatile alkali deflagrates with nitre, which proves that it contains an inflammable matter.

Volatile alkali is employed in medicine as a powerful ſtimulant and exciter, when applied ſo that the perſon ſhall inhale the vapors of it. Thus it is applied in faintings, ſyncopes, apoplexies, and in all lethargic diſeaſes, in which the nervous parts are benumbed and unbraced. In theſe caſes it is uſually applied in bottles, either in a concrete form called *Engliſh Salt*, or in a fluid form, and reduced to a ſemi-ſaponaceous ſtate by mixture with oil of amber, when it is called *Eau de Luce*. *See* SALT (ENGLISH); and EAU DE LUCE.

It may alſo be taken internally in theſe caſes, particularly in apoplexies and lethargic diſeaſes, but in ſmall doſes, as from two or three grains to ſix, and added to ſtimulant mixtures. Taken in this manner, it ſometimes is a powerful ſudorific.

M. Bernard de Juſſieu has diſcovered that this ſaline ſubſtance is a ſpecific againſt the bite of vipers; having cured as it were miraculouſly, by means of eau de luce, a ſtudent of medicine, to whom this accident happened, while he was botanizing.

XXXV. ALKALISATION. This name is applied to operations by which alkaline properties are communicated to bodies; or to thoſe by which alkali is extracted from bodies which contain it, or in which it may be formed. For example, *ſpirit of wine* is ſaid to be *alkaliſed* when it has been digeſted upon alkali, a part of which it diſſolves, and thence acquires alkaline properties. On the other hand, when a neutral ſalt is decompoſed in order to obtain its alkaline baſis, this ſalt is ſaid to be alkaliſed. Thus nitre, deprived of its acid by detonation with inflammable matters, as charcoal, tartar, metals, ſo that nothing remains but its alkali, is called *Nitre alkaliſed by Charcoal*, or *by Tartar*, &c.

Vegetable ſubſtances, when reduced to aſhes, may alſo be ſaid to be alkaliſed; becauſe theſe aſhes contain fixed alkali. *See* the detail of particular alkaliſations, under the articles of the different ALKALIS.

XXXVI. ALKOHOL. This name has been given to any impalpable powder. *See* PORPHYRISATION.

It has alſo been given to highly rectified ſpirit of wine. *See* SPIRIT *of* WINE.

XXXVII. ALLAY. This word is employed in chemiſtry to ſignify the union of different metallic matters.

As an infinity of different combinations may be made according to the nature, the number, and the proportions of the metallic matters capable of being allayed, we ſhall not here enter into the detail of the particular allays, all which are not yet nearly known. Thoſe which are uſed, as *Bronze*, *Tombac*, *Braſs*, *White Copper*, &c. may be found under their particular names; and what is known concerning other allays may be partly found under the names of the different metals, and ſemimetals, and partly in this article.

Metallic ſubſtances cannot unite directly with earthy matters, not even with their own earths, when deprived of their inflammable principle, and conſequently of their metallic properties. But in general it may be ſaid, that all metals may be allayed with each other, although more or leſs eaſily, and although ſome of them have not yet been made to unite.

As metals are bodies naturally ſolid, the firſt condition for their union is, that they be fuſed. They then unite, like all bodies which reciprocally diſſolve each other; and from theſe combinations new compounds reſult, which have the mixt properties of the component ſubſtances. *See* COMPOSITION (CHEMICAL).

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In these metallic allays, as in almost all other metallic combinations, phenomena appear which depart from the general rules of combinations. Thus it is observed, that some of the properties of metals forming an allay are altered, encreased, or diminished by their union. The ductility, for instance, of a metallic composition is generally less than the ductility of the component metals alone and pure. The density or specific gravity of metals and semimetals is also changed by allaying them with each other. Sometimes the specific gravity of the compound is intermediate betwixt the specific gravity of the component metals, sometimes it is less, and frequently greater: this depends upon the nature of the metals. The same observation may also be applied to the colors resulting from the allays of metals.

Metallic allays are either *natural* or *artificial.* The first are those made by nature, such as most minerals, containing several metals allayed with each other. Native gold is always more or less allayed with silver; and native silver with gold.

Artificial allays are those made expresly for different uses, or for the sake of examining their properties.

Although the allays of different metallic matters are of great importance to the theory and to the practice of chemistry, yet all the researches which the subject deserves, and is capable of, have not been made. Mr. Gellert is one of those who have done most in this way. In his *Metallurgic Chemistry* there are a great number of experiments, which we shall relate here summarily. The experiments made for the allaying of semimetals with metals are his own, and were undertaken to determine the specific gravities of these allays. He relates the others before known, from chemical writings, and particularly from a Dissertation of Mr. Kraaft expresly on this subject. We shall refer the allays of mercury with other metals, called Amalgams, to the word AMALGAM.

Gold may be easily united with silver, and in all proportions. Mr. Gellert says, that this allay is nearly of an intermediate gravity betwixt the gravities of the two metals, and but a very little augmented. This allay is of no use in the arts: on the contrary, as pure metals are always more ductile than allays, in the arts where ductility is requisite, as in wire-drawing, gold-beating, the purest metals are chosen. (*u*)

Silver may be easily allayed with copper, and in all proportions: copper also unites in the same manner with gold. Gellert observes that the allay of silver

(*u*) The component metals of which metallic allays are formed may be either chemically combined, that is, mutually dissolved by each other; or mechanically mixed, that is, diffused through each other by the action of fire; or they may be partly combined, and partly diffused, if the proportion of their quantities to each other be different from that which is necessary for their combination. For most, if not all, metals can be only combined with each other in certain proportions, as is very observable in those, the fusion of which requires very different degrees of heat. But those which may be kept fused in nearly the same degrees of heat may be mixed together in almost any proportion, and will be nearly uniformly diffused throughout the metallic mass when hastily cooled. As metallic allays have not been before considered in this manner, no experiments have been made to determine the proportions with which they can combine; nor can we easily establish rules by which this kind of combination can be ascertained. Those, however, which appear to me most probable, for distinguishing this combination, are, 1. When

and copper is of a greater than the intermediate gravity; but that the allay of gold and copper is of a gravity less than intermediate. Copper renders gold and silver harder and more sonorous, without much diminution of their ductility. It has even the remarkable property of rendering these two metals less susceptible of losing their ductility by the vapor of charcoal, which they are very liable to do; copper also heightens the color of gold. These properties of copper relatively to gold and silver render its allay with these metals of great use to gold and silver-smiths; because it makes them firmer, and fitter for working and chasing; and also for making money, for the same reasons; and for the payment of the Prince's duties, and for compensation of the expences of coining. The quantity of copper allayed with gold and silver for these different uses varies according to the different countries, but in each country it is fixed, and always the same.

Iron allays well with silver, and still better with gold. Gellert observes, that the gravity of an allay of gold and iron is less than the intermediate. The affinity of these two metals is very great; for gold facilitates its fusion, which indicates

When an allay possesses properties which neither of its component metals had. 2. When the properties, as the specific gravity, color, hardness, &c. of the allay, are not in an intermediate degree betwixt the same properties of the component metals, according to the proportion of these metals to each other. 3. When the component parts of an allay are not separable from each other by eliquation; that is, by applying a heat capable of fusing one of them only; nor by keeping the whole mass in fusion, with a heat not more intense than is necessary for that purpose, but insufficient to occasion an ebullition, and by cooling the melted mass very slowly. When therefore, according to these rules, a metallic allay has no properties but those which its component metals had; when its density, color, hardness, elasticity, fusibility, and other properties, are precisely in an intermediate degree betwixt those of its component metals; and lastly, when its component metals may be separated from each other by eliquation, or by giving them such a fluidity and rest as that they may separate according to their respective densities; we may then, with probability, pronounce that this allay is composed of parts not chemically combined: and when to an allay, which by these rules is composed of metals chemically combined, a quantity of one of the same kinds of metal of which the allay is composed, be added, and, upon examination, the new allay be found to possess no properties but such as are intermediate betwixt the first allay and the added metal, and to be separable by eliquation, or by their different densities, we may then consider this new allay as a mass consisting of metals partly combined, and partly diffused. That the allay mentioned in that part of the text to which this note refers, namely, that of gold with silver, does not consist of parts chemically combined, or else that but a very small proportion of each of these metals can be combined with the other, appears probable from the following reasons. 1. The density of the allay is very nearly intermediate between the densities of the component parts. 2. The silver and gold are not uniformly and equally distributed through the whole mass. This inequality is proved by an experiment of Mr. Hellot. He melted a mass of 20 pounds, containing 55 parts of silver and one part of gold, and poured it into three separate masses, each of which was found by essay to contain a different proportion of gold from the two others. 3. Gold and silver kept in gentle fusion are separable from each other, merely by their different densities. Mr. Homberg kept equal parts of gold and silver in gentle fusion a quarter of an hour, and found, upon breaking the crucible, two masses, of which the upper was pure silver, and the lower the whole gold allayed with $\frac{1}{5}$th part of silver. He repeated the experiment with nearly the same event; and twice he obtained the two metals perfectly separated from each other. *See a note to the article* AFFINITY.

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cates a ſtrong diſpoſition to unite. Gellert obſerves upon this occaſion, that therefore gold is fitter than copper for ſoldering fine works of iron and ſteel. *(w)* Iron unites difficultly with copper, and in ſmall proportion. It renders copper paler. The portion of iron which does not unite with copper forms a ſeparate regulus, which, however, ſtrongly adheres to the ſurface of the regulus of copper. The degrees of affinity of iron with other metals, according to Gellert's table, but reverſing the order in which he has placed them, (that is to ſay, beginning by thoſe with which it has the ſtrongeſt affinity, which ſeems to be the moſt natural order) are, gold, ſilver, and copper.

Tin, according to the ſame author, unites with all metals, and renders them brittle; iron and lead it alters leaſt in this reſpect. *(x)* But gold and ſilver are ſo affected by tin, that its vapor alone is capable of deſtroying the ductility of a large quantity of theſe metals, as is well known to artificers.

The allay of tin with gold and ſilver is then of no uſe; on the contrary, it is carefully avoided; but with copper tin forms an uſeful compound, known by the name of *Bronze*. The ſpecific gravity of allays of ſilver and of copper with tin is greater, and that of gold with tin is leſs than the intermediate. The affinities of tin with other metals, according to Gellert's table, (only reverſing his order, which we ſhall always do) are iron, copper, ſilver, gold.

Lead unites with all metals, excepting iron, with which no method has been found to unite it. Gellert obſerves, that this property of iron with regard to lead renders it fit to ſeparate this latter metal from others, provided that the metal from which it is to be ſeparated has not a greater diſpoſition to unite with lead, than the iron has to unite with it. This is certain, that lead may ſerve as an intermedium by which iron may be ſeparated from other metals: for inſtance, from ſilver. For if a ſufficient quantity of lead be melted with ſilver allayed with iron, it will eaſily ſeize upon the ſilver, and ſeparate the iron from it, which will then ſwim upon the ſurface of the two melted metals.

The allays of gold and of ſilver with lead have a greater ſpecific gravity, and the allays of copper and of tin with lead have a leſs ſpecific gravity, than the intermediate.

The allay of lead with other metals is uſed for the eſſays of ores, for refining, and for liquation. *See* LIQUATION.

Lead and tin are allayed together to form a ſolder for pipes and other works of lead.

The affinities of lead with other metals, according to Mr. Gellert's table, are, ſilver, gold, tin, copper.

Zinc may be allayed with all metallic matters, excepting biſmuth, with which it cannot unite, according to Mr. Gellert. This ſemimetal, when united with metallic ſubſtances, gives fuſibility to thoſe which are leſs fuſible than itſelf. The denſity of allays of gold, of ſilver, of copper, and of lead with zinc is greater; and that of allays of the ſame ſemimetal with tin, iron, and regulus of antimony, is leſs than intermediate.

(w) A very ſmall quantity of iron renders gold hard, brittle, and pale. So hard are ſome mixtures of iron and gold, that they are ſaid to have been formed into razors. Three or four parts of iron and one part of gold compoſe an allay nearly as white as ſilver.

(x) Equal parts of tin and iron form a white but brittle maſs.

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The allays of zinc with most metallic matters are not used in the arts, but that with copper is very much. This allay forms *Brass*, *Tombacs*, *Prince's Metal*, *Pinchbeck*, &c.

The affinities of zinc with other metallic matters are, according to Gellert's table, copper, iron, silver, gold, tin, lead *partly*; that is, it does not unite with lead in all proportions.

Bismuth unites with all metals, and with most semimetals. It has so great action upon other metallic substances, that it sensibly facilitates their fusion. (*y*) Bismuth renders all the metals with which it is united brittle. It does not unite with zinc; nor, according to Mr Gellert, with arsenic. When melted along with zinc, it remains at the bottom of the crucible, as being the heavier of the two; and when they are cooled, they are found forming two distinct reguli adhering strongly to each other. Gold, silver, lead, and regulus of antimony form with bismuth allays of greater, and iron forms an allay of less, than intermediate density, and copper forms with it an allay of intermediate density.

The allays of bismuth are not in use, excepting some particular metallic compositions for mirrors.

The affinities of bismuth with other metals are, according to Mr. Gellert's table, in the following order: iron, copper, tin, lead, silver, gold.

" Cobalt" *, says Mr. Gellert, " may be allayed with all metals and semi-" metals; but it acts little upon lead and silver. When equal parts of lead and " cobalt are melted together, these two substances are found only adhering to " each other, the lead being, in consequence of its greater specific gravity, at " the bottom of the crucible, and the cobalt above it; so that it seems pro-" bable that they are not at all combined. But if the same cobalt be melted, " after it has been thus treated, with iron, which seems to be the most readily " united with it of all the metals, a small regulus of lead is found at the bottom " of the crucible, because iron and lead do not unite. At first, we might be " apt to believe that silver and cobalt do not unite together. In fact, if two " parts of cobalt, and one part of silver be melted together, the silver is found " at bottom and the cobalt above, only adhering to each other: But the silver " is become more brittle, of a greyish color; and the cobalt is become whiter " than before. If this silver be cupelled, the part of the cobalt united with it " will attach itself to the cupell in form of a circle, and the silver will be found

(*y*) Bismuth greatly encreases the fusibility of some metals, as appears from the following table of Dr. Lewis, in which the degrees of heat are marked in numbers according to Fahrenheit's scale.

600. Mercury boils.
540. Lead melts.
460. Bismuth melts.
410. Tin melts.
390. Tin 8 parts, bismuth 1 part, melt.
330. Tin 2 parts, bismuth 1 part, melt.
Tin 3 parts, lead 2 parts, melt.
280. Tin and bismuth, equal parts, melt.
212. Water boils.

An allay composed of two parts of lead, three parts of tin, and five parts of bismuth, may be melted with considerably less heat than the most fusible of those mentioned in the above table.

* Note. By *Cobalt* Mr. Gellert certainly means what we call Regulus of Cobalt; for Cobalt properly called is a mineral composed of other substances besides the regulus of cobalt, as sulphur, arsenic, bismuth, silver, and unmetallic earths. *See* Cobalt.

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"to have lost an eighth part of its weight, which will be found upon essaying "the cobalt, and examining how much silver it contains." *Metallurgic Chemistry, Tom.* I.

These experiments of Mr. Gellert's prove, that regulus of cobalt cannot be united to lead and to silver in all proportions, but only in small quantity. The same may be said of bismuth, with which, says Mr. Gellert, cobalt is very easily united: for Mr. Beaumé, who has made many experiments on the regulus of cobalt, has observed, that when this regulus is melted with bismuth, these two metals are found separate, the bismuth being at the bottom of the crucible and the cobalt above it.

The allays of the regulus of cobalt are but little known, and not used in the arts.

In Mr. Gellert's table the affinities of regulus of cobalt with metallic matters are in the following order: copper, iron, tin, zinc, regulus of antimony, bismuth and lead, silver, and arsenic, partly.

Regulus of antimony may be allayed with almost all metallic substances. Mr. Gellert says, that the density of allays of this regulus with iron, tin, or zinc, is less than intermediate, and that the density of allays of this regulus with silver, copper, lead, and bismuth, is greater than intermediate. He observes also, that the magnetic property of iron is much more diminished by an allay of that metal with regulus of antimony than with any other metallic substance.

Allays of regulus of antimony are little used in the arts. It is used for some compositions for speculums. An allay of this semimetal with iron, tin, and copper, is made for the preparation of a medicine called *Lilly of Paracelsus*, or *Tincture of metals*. *See* LILLY *of* PARACELSUS.

The affinities of the regulus of antimony with metallic substances are placed by Mr. Gellert in the following order: zinc, copper, tin, lead, silver, gold. Bismuth is so placed in the table as to denote its incapacity of uniting with the regulus of antimony.

Arsenic, or its regulus, unites with most metallic matters. Mr. Gellert says, that it whitens iron; but the allay resulting from thence is very brittle. Copper is also rendered very white by mixture with arsenic. This is the *white tombac* which resembles silver. Mr. Gellert affirms, that this allay, notwithstanding it contains arsenic, is sufficiently ductile and malleable, which is very remarkable. But if it contain too much arsenic, it is brittle, and blackens in its surface. Arsenic united with tin is partly reduced to a powder like ashes, in which much arsenic remains. The rest of the tin is very brilliant, foliated, and externally resembling zinc, without being possessed of any of its properties. Tin also becomes much harder and more sonorous by this union. Lead united with arsenic smokes and swells more quickly with a moderate fire than it does alone: a part of it is dissipated in form of a thick smoke; another part is changed into a glass of a reddish yellow color; and the remaining lead is brittle, and dark-colored. Arsenic unites with silver, and renders it brittle. It does the same to gold, and also deprives it of its color, rendering it pale. It unites very difficultly with cobalt, with which it forms a black, shining matter. Lastly, Mr. Gellert (from whom all this is extracted) says, that bismuth cannot be united with arsenic.

In this author's table of affinities, the metallic ſubſtances capable of uniting with arſenic are placed in the following order, which is the ſame as that for the regulus of antimony: zinc, iron, copper, tin, lead, ſilver, gold, regulus of antimony.

The allays of arſenic uſed in the arts are white tombacs, and ſome compoſitions for ſpeculums.

It is neceſſary to remark on the ſubject of arſenical allays, that this ſingular ſubſtance has the property of uniting with metals even when deprived of phlogiſton, and in an unmetallic ſtate. This proceeds from its ſaline character, and from its property of taking phlogiſton from the imperfect metals and from the ſemimetals; conſequently there ought to be a difference betwixt the allays made with white cryſtalline arſenic, and thoſe made with the regulus of arſenic. *See* Arsenic, and Regulus *of* Arsenic. *(z)* It is proper to obſerve, that chemiſts who treat of metallic allays differ much from each other in the deſcriptions they give of the reſults of their experiments, as may be ſeen in the particular articles of each metallic matter, which ought to be conſulted on this ſubject. But theſe varieties are not ſurpriſing, when we conſider the difficulty of the matter, and the great obſtacles which prevent perfect exactneſs in theſe experiments. All who have operated much in chemiſtry will eaſily perceive, that, without reckoning the difference of proportions of the metals employed in the allays, which muſt greatly affect the reſults, others much more conſiderable would occur, depending on the purity of the metals, on the greater or leſs quantity of phlogiſton with which many of them are capable of being united, on the very variable deſtructibility and volatility of many metallic matters, and laſtly, on the juſt degrees of heat, which are of conſiderable conſequence, and which it is almoſt impoſſible to determine preciſely.

From theſe obſervations we ought to conclude, that, in order to make a ſet of accurate experiments on metallic allays, and which may be depended upon, it is, in the firſt place, neceſſary that all the metallic matters to be employed be exceedingly pure, which is a matter of great difficulty: in the ſecond place, it is proper to make all the fuſions in veſſels perfectly cloſe, to prevent the alteration, the burning, and the deſtruction of thoſe metals which are liable to thoſe events: laſtly, to determine carefully the preciſe degree of heat requiſite for the beſt combination of metallic matters with each other. But it does not appear that any perſon has hitherto done this great and important work; it is to be wiſhed that it was undertaken. How many fine experiments may then be made upon all theſe allays, to diſcover their properties!

What has been already done in this matter is, however, ſufficient to eſtabliſh ſome general truths. Several have been explained in the beginning of this article. Another evidently reſults from the experiments of M. Kraaft and M. Gellert: it is this, That as the union of all other bodies, ſo in that of metallic ſubſtances, ſome are more eaſily ſoluble, and in all proportions; others more or

(z) The author of the Dictionary has omitted, in the enumeration of allays, thoſe of platina, and of the ſemimetal diſcovered by Mr. Cronſtedt, called *Nickel*. For thoſe of platina, *ſee* the article Platina. *Nickel* may be allayed with all metallic ſubſtances excepting ſilver, mercury, and zinc. By means of nickel the two ſemimetals biſmuth and regulus of cobalt may be united. It whitens copper and gold, and it renders the malleable metals hard and brittle.

leſs difficultly, and only in certain proportions; and laſtly, others appear incapable of uniting in any manner.

On theſe two latter caſes it is very important to obſerve, that this property which certain metallic matters have of diſſolving others in certain proportions only, is very capable of impoſing on the operator, and of perſuading him that one metal cannot be united with another, becauſe he ſees after the fuſion two diſtinct reguli, while in fact there is a quantity, though frequently a very ſmall one, of one of the metals united with the other. This is ſimilar to what happens in the combination of ſpirit of wine with oils, and of water with ether. Chemiſts believed long that ether was inſoluble in water, becauſe when theſe two liquors were put in the ſame veſſel they conſtantly ſeparated, the ether, being greatly the lighter of the two, riſing upwards, and floating on the ſurface of the water. But the Count de Lauragais, having examined the matter more attentively, and in a truly chemical manner, demonſtrated, in a memoir read at the Academy of Sciences, of which he is a member, that ether is really ſoluble in water, but only in a certain proportion. *See* ETHER. This being eſtabliſhed, perhaps we ſhould find, if we were to examine all the mixtures of metallic ſubſtances, that thoſe which have hitherto been conſidered as incapable of union are, nevertheleſs, very capable of it, but only in certain proportions; and if ſome are found which cannot by ordinary fuſion be united, we might ſtill try to break their aggregation more compleatly, and to apply them to each other in this condition, as the Count de Lauragais has done with ſulphur and ſpirit of wine. *See* COMBINATION; COMPOSITION (CHEMICAL).

XXXVIII. ALUDELS. Chemiſts give this name to certain pots or capitals which are open at both the upper and lower ends, and may be inſerted and applied above each other, ſo that the whole ſhall form a pipe or tube more or leſs long according to the number of aludels compoſing it. The aludel which terminates this tube above ought to be cloſed in its upper part, or to have but a very ſmall opening. The tube compoſed of theſe aludels is nothing but a kind of capital or head, which may be enlarged or lengthened at pleaſure, and adapted to a cucurbit. This apparatus is intended to collect and retain dry and volatile matters, which may be reduced into flowers by ſublimation. It may be employed for the preparation of flowers of ſulphur, of arſenic, of antimony, of benjamin, &c. *See* SUBLIMATION. *See alſo* PLATES.

XXXIX. ALUM. Alum is a cryſtallizable ſalt compoſed of vitriolic acid united with an argillaceous earth. This ſalt has an auſtere, ſweetiſh, and ſtrongly aſtringent taſte. This ſtrong taſte proceeds from the ſtrength of union betwixt the acid and its baſe being leſs than in other vitriolic ſalts with earthy baſes; ſuch, for example, as ſelenites, which has no ſenſible taſte. Mr. Beaumé has even obſerved, that the acid of alum is not exactly ſaturated; for it is certain that it reddens turnſol and blue paper.

This ſalt diſſolves ſufficiently well in cold, but in much larger quantity in boiling water. *(a)* It is conſequently ſuſceptible of cryſtallization by the evaporation and cooling of the water in which it is diſſolved. The figure of the cryſtals of this ſalt varies, like that of other ſalts, according to the circumſtances concurring during the cryſtallization. When its ſolution, evaporated to the cryſtal-

(a) Neuman ſays, that alum requires ten times, and other authors ſay requires fourteen times, its weight of water to diſſolve it.

lizing point, is made to cool slowly, the greatest part of its crystals are found to be triangular pyramids, whose four angles seem cut off. Alum retains half its weight of water in crystallizing.

This great quantity of water in the crystals of alum, together with its property of greater solubility in hot water, is the cause that when put in an earthen or iron vessel, on a good fire, it enters into a liquefaction, which gradually diminishes as the water evaporates. When it is entirely evaporated, which is not soon, the alum which had swelled much during this operation, remains dry and friable; it is then called *Calcined Alum*. After this evaporation, it may be again dissolved in water, and crystallized as before.

Although the acid of alum appears, as its taste and solubility indicate, to be less intimately combined with its basis than the acid of selenites, yet but a very small quantity of it can be disengaged by the strongest fire. Mr. Geoffroy put some calcined alum into an earthen retort, and exposed it to a most violent fire continued during six days and six nights; and from five pounds of alum thus treated he obtained only three ounces of vitriolic acid, although it is certain that this salt contains a much greater proportion of acid, as we shall soon see. The acid thus obtained by distillation from alum is called *Spirit of Alum*; and does not differ from pure vitriolic acid.

Alum may be easily decomposed by several intermediate substances.

First, as the acid of alum is certainly the vitriolic, all substances which have a greater affinity than earths to vitriolic acid, are capable of uniting with it, and of separating from it its earthy basis.

Alum, therefore, treated properly with any matter containing phlogiston, may be decomposed; its acid uniting with it, and forming artificial sulphur. *See* SULPHUR.

It is by means of this artificial sulphur, which forms during the calcination of alum with any vegetable or animal matter, that the *pyrophorus of Homberg* is made, which has the property of burning merely by contact of air. *See* PYROPHORUS.

In the second place, all saline alkalis are capable of decomposing alum. This decomposition may be made in the humid way. If then any alkali be added to a solution of alum, the liquor immediately becomes turbid and white, and a sediment is formed, which is the earth of alum separated from its acid by the intervention of alkaline salt. On the other side, the new salt formed by the union of the acid of alum with the alkali, may be crystallized by evaporating the liquor. If fixed vegetable alkali was employed for this precipitation, vitriolated tartar is formed: if mineral alkali was employed, Glauber's salt is formed. This decomposition of alum is a very convenient method of preparing these two salts. Lastly, if volatile alkali be employed for this precipitation of the earth of alum, vitriolic ammoniacal salt will be formed.

Calcareous earths, and even some metallic substances, are capable of decomposing alum. The former are so, because their affinity is greater than that of the argillaceous earth of alum with the vitriolic acid; and the latter, for instance iron and zinc, are so, because of the slight adhesion of their phlogiston.

It appears that Mr. Geoffroy was the first who discovered that iron could decompose alum; and this he did by boiling alum in an iron pot. This experiment of Mr. Geoffroy is found in the Memoirs of the Academy of Sciences.

What

What has been said concerning these different decompositions of alum proves incontestably, that the acid of this salt is the pure vitriolic; and this truth has been known a considerable time; but till lately, the nature of the earthy basis of alum was not precisely and distinctly understood. For a long time it was considered by chemists as a calcareous earth: but accurate experiments have since shewn, that calcareous earths, united with vitriolic acid, formed selenites and not alum, which are entirely different; and that the earth of alum could not decompose sal ammoniac, nor be converted into quicklime, nor had any of the distinguishing properties of calcareous earth. These experiments have been made by Pott, Margraaf, and Baron. This last chemist, struck with the differences betwixt earth of alum and calcareous earth, and with the resemblance betwixt alum and most vitriolic salts with metallic bases, has given a Memoir to the Academy of Sciences, in which he conjectures that this earth of alum is of metallic nature.

On the other side, there were experiments which prove, that the earth of alum was contained in clays. Mr. Geoffroy and Mr. Hellot had said, that, by digesting clays with vitriolic acid, they had obtained salts of the nature of alum. Hellot, having employed a clay as an intermediate substance in the distillation of the ether of Frobenius, perceived that the vitriolic acid of this mixture had deprived the clay of all its argillaceous properties, by taking from it an earth, which being again separated from this acid by an alkali, had all the properties of pure clay. *See Memoirs of the Academy for the year 1739.* Mr. Pott, who quotes in his Lithogeognosia this experiment of Mr. Hellot, having satisfied himself with regard to the properties of the alum obtained by digesting vitriolic acid upon clay, had concluded that the earth of alum is of an argillaceous nature. *See Pott's Lithogeognosia.* Mr. Gellert in his Metallurgic Chemistry, and especially Mr. Margraaf, in three dissertations upon alum, had mentioned the same experiments, and had drawn from them the same conclusions. Lastly, Mr. Macquer, in a Memoir read at the Academy in 1762, *concerning clays and their fusibility when joined to calcareous earth,* after having quoted the above citations, which are extracted from that memoir, places the affair beyond doubt, by adding his own experiments and observations to those already made. I add," says this chemist, " to all these testimonies, that having made an accurate examina-
" tion of the properties of the earth of alum, separated from every acid, I am
" convinced, by all the proofs to which I have submitted it, that it has an entire
" and perfect resemblance to the purest clay: that is, to clay perfectly separated
" from vitriolic acid and all sandy matter. I have observed, that earth of alum,
" properly prepared, has all the argillaceous properties attributed to it by the
" above-mentioned chemists, and particularly a very binding quality. I have
" also observed, that this earth is very difficultly dried, and that it strongly re-
" tains the last portions of moisture. By drying, its bulk is considerably dimi-
" nished, which occasions it to be much cracked. It receives a polish, like all
" fat clays, when rubbed with a smooth body. If it be exposed suddenly to fire
" before it be perfectly dried, it decrepitates strongly, and bursts with great
" noise, like clays. When it has been gradually heated, and then exposed to
" a violent fire, I have observed that it has acquired a flinty hardness, and that
" by this baking and hardening in the fire it has contracted to one half in all its
" dimensions.

" Notwithstanding

"Notwithstanding this hardening, and great contraction of its size by fire, "it is remarkably refractory. It resisted the greatest violence of fire that I "was able to expose it to without shewing the least tendency to melt. Having "mixed it with fritts of crystal-glass, and different fluxes, such as fixed alkaline "salts, nitre, borax, glass of lead, I have found that these matters melted and "vitrified, without melting this earth; so that it has always communicated an "opacity to all the glasses resulting from these mixtures.

"A very remarkable property of this earth, but which, like the foregoing "properties, is common to it with clays, particularly when very pure, is, that "though its color be very white, yet this whiteness cannot be preserved: for "when it is moist it greedily absorbs all greasy, and consequently coloring par-"ticles from contiguous bodies. When exposed to moderate fire, it begins to "blacken; then it becomes more or less white, according to the nature of its "coloring matter: but to whiten it thus, it ought not to be entirely closed, but "to have a free communication with external air. Lastly, if the fire be en-"creased sufficiently to harden well and bake this earth; then in whatever man-"ner, and with whatever attention it may have been prepared, it never fails to "resume so much more color as it is heated more intensely. It takes all sorts "of tints, yellowish, greenish, bluish, grey, brown; and some I have seen be-"come quite black. I have already observed, that the same thing happens to "natural clays, when well deprived of sand.

"This property denotes a very great disposition in this earth of uniting with "the principle of inflammability, and of retaining it strongly when once united. "This may give occasion to conjecture that the earths of metals, and those "which are disposed to metallisation, are essentially of argillaceous nature; and "this idea adds a new probability to the opinion of Mr. Baron, who, in a me-"moir upon the earth of alum, conjectures that this earth is of metallic nature, "although not really reducible into metal, at least by any processes hitherto "ascertained, and sufficiently known.

"However that be, it appears well ascertained by the chemical experiments "quoted above, and by mine, that earth of alum is a pure clay, free from all "mixture of vitrescible earth; and that all natural clays are mixtures of greater "or less quantities of this pure argillaceous earth, which is capable of com-"bining with vitriolic acid, and of forming with it alum; and of another sub-"stance of different nature, which in its natural state cannot combine with vi-"triolic acid, and which Mr. Margraaf considers as a true sand, as indeed it "has all the marks of that kind of earth.

"From all this it may be inferred, that in all natural clays there is only this "portion capable of forming alum with a vitriolic acid, which is a true argilla-"ceous earth; and that the other portion is of a nature entirely different." *See* CLAY.

Alum is capable of decomposing nitre and common salt, in consequence of the vitriolic acid it contains. The nitrous and marine acids may even be obtained more pure by means of alum than of any other substance.

All the alum which is in commerce is extracted by different operations from several pyritous, earthy, or stony matters, containing the vitriolic acid and the earth proper for forming this salt.

The pyrites or pyritous matters from which alum is extracted, ought to have effloresced in open air, or to have been calcined in the fire, to allow the vitriolic acid of the sulphur which they contain to disengage itself. This acid meeting in the pyrites itself the argillaceous earth proper to form alum, does in fact there combine with it and form that salt; which is afterwards extracted by lixiviation, evaporation, and crystallization, as is practised for all salts. Much of these pyrites or pyritous stones furnishing alum are found in Sweden, England, Germany, and France, and they are worked by the general processes we have mentioned. But to have a clear idea of what passes in these operations, it is necessary to know pyrites, and its nature; for which reason see the word PYRITES.

XL. ROCK-ALUM. The alum which is extracted from pyritous mineral matters is seldom very pure, on account of the vitriolic metallic substances always contained in pyrites. I have examined many of these alums, and by the proofs made of them, I have found that they always contained a greater or less quantity of martial vitriol. This alum is in commerce called rock-alum, because much of it is extracted from pyritous rocks or stones. It appears that the names *Ice-alum* and *Rock-alum* are synonimous and confounded in commerce, because there is no difference in the price. Frequently these alums, which are in great masses, like stones, (which may also have contributed to the name Rock-alum) have a reddish tinge. These are the impurest, and contain most martial vitriol.

A large quantity of pure alum is extracted from the neighbourhood of Puzzoli, near Naples, at a place called *Solfatara*. *See* SULPHUR.

The Abbé Nollet, who visited this place, and examined the works established there, says, in the Memoirs of the Academy, that the matter from which the alum is extracted, is an earth similar in its consistence and color to the marle found in the same plain. I have examined this earth, and have found that it has the appearance, and nearly the consistence of white marle: but it differs essentially from marle in not effervescing with nitrous acid.

Caldrons of lead, two feet and a half in diameter, and as much in depth, are filled with this earth or stone to three quarters of their contents. These caldrons are sunk so as to be almost on a level with the ground under a great shed, at about the distance of four hundred paces from the sulphur furnaces. Water is thrown into each caldron, till it rises three or four inches above the earth. The natural heat of the ground of this place is sufficient to heat the matter, as it makes Mr. Reaumur's Thermometer rise thirty-seven degrees and a half above the freezing point: and thus fuel is spared. By means of this digestion, says the Abbé Nollet, the saline part is disengaged from the earth, and rises to the surface, whence large crystals are extracted.

The alum in this state is mixed with much impurities. It is carried to a building at the entry into the Solfatara, and it is dissolved with hot water in a great stone vessel shaped like a funnel. The alum is there crystallized again by the heat only of the ground, and becomes purer.

XLI. PLUME-ALUM. This name is given to two very different substances. One is a matter truly saline, which tastes and dissolves in water like alum, and crystallizes in form of feathers. This kind of alum, which is native, is found crystallized in grottos where aluminous mineral waters pass. Mr. Tournefort observed it in his voyage into the Levant. It is rare, and not

found in commerce. The other matter to which the name of plume-alum has been very improperly given, is nothing else than a *friable amianthus* or *asbestus*. (b)

XLII. ROMAN ALUM. In the territory of Civita Vecchia, about fourteen leagues from Rome, is found a hard stone whence a great deal of very fine and pure alum is extracted. The place where this stone is found and manufactured, is called *Aluminera della Tolfa*. This stone, which is neither pyritous nor calcareous, is manufactured by calcining it, as limestone is, for twelve or fourteen hours, after having broken it in pieces. This stone thus calcined is laid in several heaps upon places surrounded by ditches filled with water. It is sprinkled with this water three or four times each day, for forty days, or till the calcined stone enters into a kind of effervescence, and is covered with a reddish efflorescence. Then the stones are boiled with water in caldrons to dissolve all the alum which is formed, and the water is then evaporated to the point of crystallization. This water is made to flow quite hot into oaken vessels, where, by cooling, a great quantity of irregular crystals are formed of a pale reddish tinge. In this state the Roman alum is sold. It is not in large masses like rock-alum, but in lumps of the size of almonds, nuts, or eggs. This alum is also mixed with much reddish dust. I have carefully examined the purity of Roman alum, and I have found it to exceed much the purity of rock-alum. It contains no metallic or vitriolic matters; and is therefore preferred for certain dyes, the beauty of which is hurt by the smallest quantity of martial vitriol. Its price also is greater than that of rock-alum. (c)

Alum is very useful in several arts, and chiefly in dying, to which it is essentially necessary, as it heightens the intensity and lustre of most colors. It is even absolutely necessary to give solidity to all those colors which reside in gummy substances. Without alum, these dyes would be only confused stains, which might be washed out by water. *See* DYING.

Alum is an astringent drug of powerful efficacy; consequently it is proper for diseases where the principal indications are to fortify and constringe, as

(b) Alum is sometimes found native with a lanuginous or plumose appearance, and it is then called *plume alum*. It is probably formed by the decomposition of pyrites, or some compound containing sulphur, and clay. By the dissipation of the phlogiston of the sulphur, the vitriolic acid is disengaged, and unites with the argillaceous earth, forming alum.

The name *plume-alum* is also frequently given to a striated stone of the asbestus kind, called also *false asbestus*. *See* ASBESTUS.

Lastly, this name is given by Basil Valentine, and other alchemical authors, to a compound formed of arsenic united with vitriolic acid.

(c) A remarkable circumstance attends the crystallization of alum, namely, that good crystals of this salt cannot be formed, unless an alkaline lixivium or urine be added to the lixivium of alum when set to crystallize. Chemists supposed that by adding these alkaline matters, some metallic or impure earthy substance which prevented the crystallization was precipitated; but Mr. Margraaf found by experiments that he could not form good crystals by combining vitriolic acid with earth of alum, with calcined alum, or with clay, unless he added a lixivium of fixed or volatile alkali, or urine. He supposes that these alkaline lixiviums produce their effect either by engaging a superabundant acid, or some greasy matter which prevents the crystallization.

for-

for immoderate menſtrual and lochial diſcharges, loſſes of blood, fluor albus, diarrheas, hæmorrhages, vomitings of blood, and even ſome kinds of hemoptoes. But it is neceſſary to obſerve on the ſubject of this remedy, and even of all other aſtringents, that they ought only to be preſcribed by intelligent phyſicians, who can diſtinguiſh whether or not theſe diſeaſes proceed from or are accompanied with inflammation, or too great plenitude: for in theſe caſes, aſtringents, ſo far from being uſeful, muſt be pernicious, and increaſe the cauſe of the evil. Alum is improper in theſe maladies, but when it is evident that they proceed from a mere relaxation, or from a rupture of the veſſels: in theſe caſes it has excellent effects.

As alum is one of the ſtrongeſt aſtringents, and as it is even ſomewhat cauſtic, ſeveral intelligent phyſicians, as Mr. Cartheuſer, and Mr. Baron, in his Notes on Lemery's Chemiſtry prohibit the internal uſe of it; notwithſtanding which it is every day uſed ſucceſsfully in the above-mentioned caſes. However, it is prudent to adminiſter alum at firſt in very ſmall doſes only, as two or three grains except in very urgent caſes, where it may be given to ten or twelve. It may be given either alone, or joined with other aſtringent or blunting medicines, according to the particular indications.

Alum being ſuſceptible of decompoſition by all alkaline and calcareous matters, it muſt not be mixed with theſe ſubſtances, when intended to act as an aſtringent. Alum is often uſed externally; it conſtringes and fortifies conſiderably the parts to which it is applied: conſequently it is an efficacious repellent, and is uſeful in collyriums and in aſtringent gargariſms. When calcined, its powder is ſprinkled on ſoft and fungous fleſh, which prevents the cicatriſation of ulcers. It abſorbs their moiſture, dries and conſumes them.

XLIII. ALUMINOUS. Whatever contains alum, or partakes of the nature of that ſalt is called aluminous.

XLIV. ALKANET. (*d*)

XLV. ALMONDS. (*e*)

XLVI. ALOES. (*f*)

XLVII. ALTHEA. (*g*)

(*d*) Alkanet. The cortical part of the root of this plant, which is a kind of Bugloſs, contains a red colorific matter, capable of being extracted by oils, by wax, and by ſpirit of wine. Wax thus colored, applied to warm marble, leaves a red ſtain.

(*e*) Almonds, *ſweet* and *bitter*, contain an expreſſible oil and farinaceous earth. The bitter part of bitter almonds is not expreſſed with the oil, but may be diſſolved by digeſtion in aqueous and in ſpirituous liquors, and with theſe may be diſtilled. Waters diſtilled from bitter almonds, or from moſt other bitter vegetables, fruits, and flowers, which have a ſimilar flavor to them, are poiſonous to birds, to ſome animals, and have ſometimes been ſo to men.

(*f*) Aloes is an inſpiſſated bitter juice extracted from the leaves of a plant of the ſame name. It is partly gummy, and partly reſinous; and the gum and reſin are ſo well mixed together, that moſt of the juice is ſoluble either in aqueous or ſpirituous menſtruums.

(*g*) Althea, or *Marſh-mallow*. Two ounces of the root of althea yielded, with water, ten drams and fifty grains of mucilaginous extract; and afterwards, with ſpirit, forty-one grains of reſin. The ſame quantity of that root treated firſt with ſpirit gave ſix drams of a reſinous extract, a conſiderable part of the mucilage diſſolving in that menſtruum along with the reſin. The remainder boiled in water gave five drams and forty-eight grains of pure mucilage. The indiſſoluble earthy part was one-fourth part of the root, and one half of the leaves of althea. *Neuman*.

XLVIII. AMALGAM. This word is applied to the allays of metallic matters with mercury.

Mercury being a metallic ſubſtance cannot contract any union with earthy matters, not even with the earths of metals, when deprived of their phlogiſton, and their metallic form. But it is capable of being allayed more or leſs eaſily with almoſt all metallic ſubſtances.

As mercury is habitually fluid, as it ought to be conſidered as a metal perpetually in fuſion, and as it is ſufficient for moſt combinations that one of the two bodies that are to be combined be fluid, it follows that without the help of heat, mercury may be amalgamated with many metallic ſubſtances. There are two methods generally uſed of making amalgamas. The firſt is merely by trituration, and without heat. The ſecond is by fuſing the metal which is to be amalgamated, and by adding to it, when fuſed, the intended quantity of mercury.

Metals, by their union with mercury, become friable and capable of being pulverized, when the mercury is only in ſmall quantity. But when the mercury is added in larger quantities, the metals are by it reduced to kinds of paſte, which has no ductility nor tenacity.

Of all metals, gold has the greateſt affinity to mercury, and unites with it moſt eaſily. For this purpoſe nothing more is requiſite than that the mercury ſhould be ſlightly rubbed on a piece of gold, or that it remain ſome time in a golden veſſel. The ſurface of the gold which has touched the mercury becomes white as ſilver; and if the gold is thin, its conſiſtence is deſtroyed in that place, ſo that it very eaſily breaks. But the amalgamation of mercury with gold is conſiderably accelerated by dividing the gold into very ſmall parts or very thin plates. All metals ought to be ſo divided, when they are to be amalgamated by trituration without fuſion or heat. *(b)*

Silver may be amalgamated nearly in the ſame manner as gold. Mr. Gellert has obſerved a ſingular and remarkable phenomenon in this amalgam, which is, that its ſpecific gravity is not only greater than the intermediate ſpecific gravity of the mercury and of the ſilver, but that it is even greater than the ſpecific gravity of mercury, although ſilver be greatly lighter. *See* SILVER *and* MERCURY.

Mr. Gellert aſcertained this fact, not only by obſerving that the amalgam of ſilver ſinks to the bottom of a veſſel containing mercury, but alſo by the exact hydroſtatical experiment. *See his Metallurgic Chemiſtry. Tom. I.*

The amalgams of gold and ſilver, and particularly the firſt, are much uſed for the ſeparation of theſe two metals from their ores, or rather from the earthy

(b) As an amalgam of gold is much uſed for gilding metals, we ſhall mention that the plates or grains of that metal may be more eaſily and perfectly amalgamated by applying them heated hot to the mercury, which ought alſo to be previouſly heated till it begins to ſmoke, and by ſtirring the mixture with an iron rod till the gold diſappears, which will be very ſoon. When the quantity of mercury is ſo large that the maſs is fluid when cold, the ſuperfluous part of it may be ſeparated by paſſing it through ſoft leather: this contains a very ſmall portion of gold. The remaining amalgam has the conſiſtence of butter, and contains about one part of mercury to two parts of gold, but is nearly as white as ſilver.

and ſtony matters with which they are mixed. *See* Ores *of* Gold, and of Silver. Theſe amalgams are alſo uſed for ſome kinds of *gilding* and *ſilvering*. See theſe two words. The amalgam of ſilver is alſo employed for the *Arbor Dianæ*. *See* Arbor Dianæ.

The amalgamation of all metals with mercury is much facilitated by heat. But the amalgamation of thoſe metals which unite difficultly with mercury cannot be effected without heat. For this purpoſe, the mercury ought to be heated till it begins to riſe in vapors; and the metals of difficult fuſion, which we ſuppoſe to have been previouſly divided into ſmall parts, ought to be made red by fire, and quickly triturated with the hot mercury. As to the metals which melt before they become red, ſuch as tin and lead, it is ſufficient to melt them, and to throw the mercury upon them, ſtirring a little the mixture: and thus the amalgam is made in an inſtant.

It would be very imprudent to melt metals which require a great heat for their fuſion, as copper, for inſtance, and to add mercury to this melted metal, with an intention to make an amalgam; becauſe not only the greateſt part of the mercury would be diſſipated in vapors before it could be united to the metal, but alſo becauſe there would be great danger of exploſion from the mercury, which being a rarefiable and volatile body, is capable, like all ſuch bodies, of producing this effect, when they are ſuddenly expoſed to too great heat.

Mercury amalgamates difficultly with copper, more difficultly with regulus of antimony, not at all with iron *(i)*, nor, as Mr. Gellert ſays, with cobalt. But with all the other metals and ſemi-metals it may be eaſily amalgamated.

The amalgam of mercury with tin is much uſed for covering one of the ſurfaces of mirrors, and thus rendering them capable of repreſenting images more ſenſibly and perfectly. *See* Tinning *of* Looking-Glasses. This amalgam is alſo uſed for the preparation of mercury-balls, intended to purify water. *See* Balls (Mercury).

Biſmuth when amalgamated with mercury has the ſingular property of ſo attenuating lead added to this amalgam, that a great part of this metal may be paſſed through leather along with the mercury. Mr. Cramer adviſes, in order to make this experiment ſucceed, to melt the lead firſt with the biſmuth, and to this mixture to add the mercury. He further ſays, that if this amalgam be digeſted ſeveral days, the biſmuth will be ſeparated, and will leave the attenuated lead united to the mercury.

Regulus of antimony can, as was ſaid above, very difficultly, be united with mercury. Mr. Gellert ſays, that to make this amalgam ſucceed, the regulus ought to be put into hot mercury, and the whole covered with water. But that when the regulus of antimony has been prepared by means of iron, or an alkaline earth, this amalgam may be made much better, ſo that the regulus ſhall not ſeparate, after ſtanding ſome time, from the mercury, as it uſually does.

(i) Dr. Lewis obſerves, that mercury adheres to, and coats the ends of iron peſtles uſed for the trituration of amalgams, and that a plate of tough iron may be rendered brittle by keeping it immerſed in mercury during ſome days. This experiment did not ſucceed with me. Hence he infers, that mercury is not incapable of acting upon iron.

The affinities of metallic ſubſtances with mercury are placed, according to Mr. Geoffroy, in the following order: gold, ſilver, lead, copper, zinc, regulus of antimony.

According to Mr. Gellert's table, they are, gold, ſilver, biſmuth, zinc, tin, lead, copper, regulus of antimony.

As the amalgams of mercury are true allays of metallic ſubſtances, all the general properties of allays are applicable to them. *See* ALLAY.

XLIX. AMBER. *See* BITUMEN.

L. AMBERGRISE. Is a ſubſtance of a grey color, which moſt chemiſts and naturaliſts have claſſed amongſt bitumens, rather from its properties and the principles it yields by diſtillation, than from any certain knowledge of its origin. For it does not appear that any truly foſſil ambergriſe is known, and that any is found in commerce, but what is procured from the Indian ſeas upon which it floats in the neighbourhood of the Molucca iſlands.

Mr. Cartheuſer thinks that ambergiſe ought certainly to be conſidered as a bitumen; and he is determined to this opinion from the analyſes made of it by ſeveral chemiſts, and particularly by Neuman. From which analyſes it appears, that the ſame principles were obtained from ambergriſe as from amber, that is to ſay, phlegm, a volatile acid, partly fluid and partly ſolid, oil, and a little coaly matter.

Beſides, ambergriſe is nearly as difficultly ſoluble as amber and other bitumens in different menſtruums: but it differs from amber in this, that it is much ſofter, is not ſmooth, nor is capable of taking a poliſh. Further, it is not tranſparent, and is capable of fuſion. The heat of the hands alone is ſufficient to ſoften it like wax. It alſo leaves much leſs coaly reſiduum than amber, after diſtillation. All theſe properties denote that ambergriſe is much more oily than amber.

The agreeable ſmell of ambergriſe renders it uſeful in perfumes. Muſk however is always joined with it, or ſubſtituted for it; not becauſe muſk is cheaper, for it alſo is very dear, but becauſe its ſmell is greatly ſtronger, and goes farther in the preparation of perfumes.

Ambergriſe is alſo uſeful in medicine. It has the ſame general virtues as all the odoriferous ſubſtances, from the ſpiritus rector or highly attenuated and volatile oil, which is the principle of their ſmell. It enters into the compoſition of many cordial, ſudorific, and alexiterial waters. It is alſo ſaid to be a venereal ſtimulant. But its chief virtue conſiſts in its antiſpaſmodic and ſedative qualities ſimilar to thoſe of muſk and caſtor, and in its power of relieving certain hyſterical, convulſive, and other nervous affections. It may be taken inwardly from half a grain to ten or twelve grains or more. For, as to doſes, there can be no fixed rules about remedies and diſeaſes of theſe kinds.

LI. AMMONIAC (SALT). All neutral ſalts compoſed of any acid ſaturated with volatile alkali, may be called ammoniac ſalts. But the name *Sal-ammoniac* is more eſpecially appropriated to the neutral ſalt reſulting from the union of the acid of common ſalt with volatile alkali. All the other ammoniacal ſalts are ſpecified by particular epithets, as *vitriolic ammoniacal ſalt*, *nitrous ammoniacal ſalt*, and *vegetable ammoniacal ſalt*. We ſhall ſpeak ſucceſſively of theſe ſeveral ſalts.

All ammoniacal ſalts have the general properties of neutral ſalts, compoſed of acids and alkalis. But they differ from the neutral ſalts whoſe baſes are

fixed

fixed alkalis, by their more pungent taste, which proceeds from the less adhesion of acids in general with volatile alkali than with fixed alkali; in the second place, by their less fixity, all the ammoniacal salts being semi-volatile, that is, capable of subliming to a certain height, when exposed to a strong enough fire. This property proceeds from the volatility of their alkaline bases. Lastly, ammoniacal salts are susceptible of decomposition by many substances not capable of producing the same effect on neutral salts whose bases are fixed alkali; as we shall see by a more particular examination of the properties of these salts.

The most generally known and used ammoniacal salt is that which contains the acid of common salt. This salt, when very pure, is very white, semitransparent, capable of forming feather-like crystals, or of subliming in close vessels into a compact striated mass.

This salt is easily soluble in water. It deliquiates into a liquor when exposed some time to a moist air. It is one of the salts which produce the most cold during its solution in water. This generation of cold is so much as to sink the thermometer eighteen or twenty degrees, and even more, according to the temperature of the atmosphere. It appears that the hotter this temperature is, the greater cold is generated, which proceeds from the greater and quicker solubility of this salt in warm than in cold water. Mr. Gellert [*Metallurgic Chemistry, tom.* 1.] says, that if any gum or resin be boiled in water impregnated with sal ammoniac, these substances will be dissolved in it. It is not surprizing that gums should be thus dissolved, considering that water is their proper menstruum. But as pure water does not at all attack resins, their solution in Mr. Gellert's experiment must proceed from the sal ammoniac.

Sal ammoniac cannot be decomposed merely by the action of fire in close vessels; because it then entirely sublimes, as we have already observed. To decompose it therefore, we must employ some intermediate substance capable of disengaging either its acid or its alkali.

The acids having, from their several affinities, the same relations to volatile alkali as they have to fixed alkali, (*See* ALKALI VOLATILE) it follows that sal ammoniac ought to furnish the same phenomena of decomposition by the vitriolic and nitrous acids, as common salt does. These two acids then are capable of decomposing sal ammoniac, by separating its acid, which passes alone in distillation, and by uniting themselves with the volatile alkali, with which the first forms a vitriolic ammoniacal salt, and the second a nitrous ammoniacal salt.

It is proper to observe upon the decomposition of sal ammoniac by nitrous acid, 1. That the marine acid does not rise singly in distillation, but is always accompanied with a good deal of nitrous acid, which rises in consequence of its volatility, and, together with the marine acid disengaged from the sal ammoniac, forms an *aqua regia*. 2. That in this operation great management, slowness, and precautions are necessary, particularly if smoking spirit of nitre be employed; because the vapors which pass are more expansible, and less condensible than the pure vapors of the nitrous or of the marine acids, which difference undoubtedly proceeds from the reaction of these two acids upon each other. 3. That it is very necessary to attend carefully to the fire towards the end of the distillation, and when the matter remaining in the retort begins to be dry; because it is a nitrous ammoniacal salt, which has the property of detonating alone, and with

little

little heat. Prudence therefore requires that the diſtillation be not puſhed to perfect dryneſs. There is ſcarcely any operation in chemiſtry ſo liable to an exploſion as this is. *See* AMMONIAC (NITROUS SAL).

Sal ammoniac is alſo capable of decompoſition by many ſubſtances, which, by uniting with its acid, ſet at liberty its volatile alkali.

These ſubſtances are calcareous earths, quicklime, fixed alkalis, and metallic matters. The moſt eſſential phenomena which this ſalt exhibits, when treated by theſe different matters, are the following:

If powdered ſal ammoniac be mixed with twice its weight of any calcareous earth, of chalk for example, alſo powdered, and the mixture be diſtilled with a proper apparatus, (*See* DISTILLATION) a large quantity of volatile alkali will paſs into the receiver, in a concrete form, very white and very beautiful, lining all the inſide of the receiver; and when the operation is over, we ſhall find in the retort a maſs containing all the acid of the ſal ammoniac, engaged and retained in the calcareous earth: if conſequently this caput mortuum be lixiviated, in order to diſſolve all its ſaline part, we ſhall find that this lixivium is impregnated with much marine ſalt with earthy baſis. See for the properties of this ſalt ACID (MARINE), and SALT (MARINE) *with* EARTHY BASIS.

In this operation a true decompoſition happens of the ſal ammoniac by the intervention of the calcareous earth. Mr. Duhamel ſeems to have been the firſt who diſcovered and publiſhed this decompoſition. He has obſerved, that the volatile alkali of the ſal ammoniac, when it diſengages itſelf in this operation, carries off with it a part of the calcareous earth. We ſhall ſoon ſee that it alſo carries off part of other ſubſtances employed to diſengage it.

Mr. Beaumé, who has ſince repeated this experiment with his uſual accuracy, and in great quantities, has obſerved, that a quantity of volatile alkali may be obtained by this diſtillation equal in weight to the ſal ammoniac employed, altho' it be certain, that there is nearly as much marine acid as volatile alkali contained in ſal ammoniac. *(k)*

This ſalt treated with quicklime is ſtill more eaſily decompoſed than with uncalcined calcareous earth. To make this decompoſition, and to obtain the volatile alkali, powdered ſal ammoniac muſt be quickly mixed with twice its weight of quicklime, ſlaked by expoſure to air, and the mixture muſt be quickly put into a great ſtone-ware retort, to which a receiver muſt be immediately

(*k*) Mr. Duhamel and other authors have attributed this great encreaſe of weight gained by volatile alkali, during its ſeparation from the marine acid in the decompoſition of ſal ammoniac, by intervention of chalk, or other mild calcareous earth, or mild fixed alkali, to part of the ſubſtance of the earth, or fixed alkali, being carried along with the volatile alkali. The ſubſtance which volatile alkali does receive from theſe intermediate matters is not, as theſe authors have ſuppoſed, earthy, or alkaline, but is the fixable air which is ſeparated from them, when they combine with the acid of the ſal ammoniac. In this operation, therefore, we have an inſtance of what our author calls *double affinity*; (*See* AFFINITY) the acid of the ſal ammoniac combining with the earthy part of the chalk, or with the ſaline part of the mild alkali, and the volatile alkali of ſal ammoniac combining at the ſame time with the fixable air of the chalk, or of the mild alkali. That this addition of fixable air to the volatile alkali is ſufficient to render its weight equal to that of the ſal ammoniac employed, appears from Mr. Cavendiſh's experiments, which ſhew, that more than half of the weight of mild volatile alkali is fixable air. *See* AIR (FIXABLE), and ALKALI (VOLATILE).

luted

luted. *See* DISTILLATION. The action of the quicklime upon the sal ammoniac is so quick, that a good deal of volatile alkali is disengaged as soon as the two matters are mixed together, which obliges the operator to take care not to expose himself to breathe the vapors. The heat must also be attended to in this distillation, particularly at the beginning; because then it is performed almost without fire.

It is very remarkable that volatile alkali obtained by intervention of quicklime, never is, nor can be, in a concrete form, by any method. It is always liquid, and is called *volatile spirit of sal ammoniac.* It is evident that it is by means of the water contained in a large quantity in the slaked lime, and in which the volatile alkali is dissolved, that it thus appears in a liquid state; but it is certain that this saline matter so strongly adheres to this water, that it cannot be separated without some intermediate substance; and that, on the other side, this same water is so necessary to its separation from the marine acid by the intervention of the lime, that Mr. Duhamel could not obtain volatile alkali by trying to decompose sal ammoniac with quicklime in the state it is in when newly calcined, and still hot from the kiln, and consequently perfectly dry. *(l)*

This volatile alkali, although it be diffused in much water, is still more active and more penetrating than that which is obtained by the intervention of other substances in a dry and concrete state. Mr. Beaumé has observed, that the volatile spirit of sal ammoniac made with quicklime, when poured into a solution of any salt with earthy basis, does not produce the same effects as the same alkali of sal ammoniac which has been disengaged by calcareous earths or fixed alkalis, and which may always be procured in a concrete state; as this latter volatile alkali easily decomposes these salts with earthy bases, and occasions a copious white precipitate to fall from their solutions, while the former does not appear to produce any effect, but only occasions a very light whitish cloud. *(m)*

These differences prove that a singular alteration is produced upon volatile alkali by quicklime; and this alteration is probably caused by the quicklime depriving it of part of its inflammable principle by help of which it seems crystallizable, and consequently by a partial decomposition of it. Another phenomenon, no less important, supports this opinion; which is, that if volatile spirit of sal ammoniac be frequently distilled from new quicklime each time, we may easily perceive that there is a considerable quantity of it entirely decomposed by each

(l) The volatile alkali obtained by this process is caustic or uncombined with fixable air, and is therefore, as we have observed under the article VOLATILE ALKALI, always in a liquid state. This liquid volatile alkali may also be obtained by employing caustic fixed alkali instead of the quicklime. From Mr. Duhamel's experiment mentioned in the text, by which he found that volatile alkali could not be obtained in this process, unless water was combined with the quicklime, it appears probable, that this operation also is an instance of double affinity, and differing only from the former operation in this respect; that in this process the volatile alkali receives water, and in the former it receives fixable air, from the calcareous earth.

(m) Caustic or uncombined volatile alkali does not precipitate calcareous earths from acids; because its power of combination with acids does not seem to be stronger than that of those earths. But mild volatile alkali acts upon salts with bases of calcareous earth, by what our author calls double affinity; that is, its alkaline part combines with the acid of those salts, while its fixable air combines with the calcareous earth.

distillation;

diſtillation; and that, on the other ſide, if, as Mr. Duhamel did, we lixiviate quicklime in a large quantity of water, till it makes no longer cream of lime, nor has the properties of quicklime; and if the lime thus decalcined, and reduced to the ſtate of mere calcareous earth, be employed for the decompoſition of ſal ammoniac, we ſhall then obtain a concrete volatile alkali, as if a calcareous earth had been uſed, which had never been calcined. *See* QUICKLIME. (*n*)

When ſal ammoniac is decompoſed by the intervention of quicklime, in the retort is found a ſaline earthy matter; that is, a part of the quicklime above what was neceſſary for the decompoſition, and another part ſaturated with the acid of ſal ammoniac, and forming a ſort of ſea-ſalt with earthy baſis, which ſeems to be ſimilar to that ſalt formed by uniting marine acid with an uncalcined calcareous earth, but which ought to differ from it in many reſpects, and particularly by a ſtronger adheſion of the acid to the quicklime. (*o*) This ſalt, when dry, is called improperly *fixed ſal ammoniac*, and when deliquiated into a liquor, it is called *oil of lime*, or *liquid ſhell*.

Fixed alkali, either vegetable or mineral, eaſily decompoſes ſal ammoniac, and ſeparates from it by diſtillation the volatile alkali in a concrete ſtate, if there be little or no water in theſe matters: but if theſe matters contain water, or if water be deſignedly added, the alkali, which is more volatile than the water, paſſes firſt, partly in a concrete ſtate, then the water which riſes diſſolves it wholly or partly, according to the quantity of water, and it is thus reduced to a liquid ſtate. Mr. Duhamel obſerves, that in this diſtillation alſo the volatile alkali carries off with it a portion of the fixed alkali which is employed to diſengage it. (*p*)

The ſalt remaining in the retort after this diſtillation is common ſalt, entirely ſimilar to ordinary ſea-ſalt, if the fixed alkali employed was the mineral alkali; and ſimilar to regenerated ſea-ſalt, or ſalt of Sylvius, if the vegetable fixed alkali was employed. *See* SALT (COMMON).

Moſt metallic ſubſtances alſo act upon ſal ammoniac, and are capable of decompoſing it.

Silver, copper, iron, tin, lead, and mercury, well mixed with this ſalt, and diſtilled together, diſengage its volatile alkali. The ſemimetals alſo produce the ſame effect. After the diſtillation is finiſhed, the metal is found combined with the acid of ſal ammoniac. This ſilver becomes *luna cornea*, and lead becomes *plumbum corneum*. In this manner Mr. Margraaf prepared his *plumbum corneum* which he employed in his operation for phoſphorus. *See* PLUMBUM CORNEUM; and PHOSPHORUS.

A remarkable thing occurs in this decompoſition of ſal ammoniac by lead, for which Mr. Margraaf requires a calx of lead, ſuch as minium, rather than lead

(*n*) Mr. Duhamel evidently reduced his quicklime to mild calcareous earth, that is, combined it with fixable air; we need not, therefore, wonder that the volatile alkali which he obtained was alſo mild, or combined with that air.

(*o*) The ſalt formed by decompoſing ſal ammoniac with quicklime is preciſely the ſame as the ſalt formed by uniting marine acid with uncalcined calcareous earth: for the acid, uniting with uncalcined calcareous earth, deprives it of its fixable air, and reduces it to the ſame ſtate as the calcined earth, or quicklime is in.

(*p*) See the note (*i*).

itſelf, for the conveniency of the mixture; which is, that the volatile alkali which paſſes over in the diſtillation, altho' very ſtrong and much dephlegmated, is always in a liquid or fluor ſtate, which ſhews, that upon this occaſion, as in many others, metallic calces produce the ſame effect as quicklime.

As to mercury, it very certainly decompoſes ſal ammoniac, and ſeparates its volatile alkali. But if more ſal ammoniac was added than the mercury can decompoſe, this undecompoſed part of the ſalt remains united with the combination of marine acid with mercury, and cannot by cryſtallization or ſublimation be ſeparated from thence. This fact has been aſcertained by Mr. Macquer; of which a detail is given in his Memoir upon the *Count de la Garaye's Tincture of Mercury*, printed in the collection of the Academy of Sciences in the year 1755.

Junker ſays, that regulus of antimony treated with ſal ammoniac diſengages the volatile alkali, and is converted into butter of antimony.

It is proper to obſerve on this occaſion, of the decompoſition of ſal ammoniac by earthy and metallic ſubſtances, which unite with its acid and diſengage its volatile alkali, that as the volatile alkali thus diſengaged is capable of ſeparating in its turn all theſe ſame ſubſtances united to an acid, and even to the marine acid, there ſeems to be ſomething contradictory in the affinities of volatile alkali, and of earthy and metallic ſubſtances. Mr. Baron, in his Memoir upon Borax, and Mr. Macquer, in his Elements of Practical Chemiſtry, explain theſe effects in a plauſible manner, by the great difference of the fixity and volatility of theſe ſubſtances. It appears nevertheleſs that the ſubject is ſtill ſomewhat obſcure, and requires a more particular examination.

If, inſtead of mixing with ſal ammoniac ſufficient quantities of copper, iron, and even of moſt other metals, and with proper circumſtances for the decompoſition, theſe metals were employed in a ſmaller quantity, and that the heat was immediately raiſed ſufficiently intenſe for ſublimation, the ſal ammoniac would then be obtained ſublimed, or flowers of undecompoſed ſal ammoniac would be raiſed, containing ſome part of the metals. By this method chemical preparations or medicines are made, which are named from the metals employed. Thus flowers of ſal ammoniac impregnated with copper are called *ens veneris*; thoſe impregnated with iron, are called *martial flowers of ſal ammoniac*, or *martial flowers*, or *ens martis*. See *theſe words*.

There are alſo other properties of ſal ammoniac which ought to be mentioned here.

This is one of thoſe ſalts which are ſoluble in ſpirit of wine. Mr. Macquer, in the above quoted memoir, has determined that thirty-two parts of well rectified ſpirit of wine are neceſſary for the ſolution of one part of ſal ammoniac.

Sal ammoniac acts conſiderably on mercury ſublimate corroſive. It diſſolves this ſalt and unites with it, and occaſions no decompoſition to either of the ſalts. From the union of theſe two ſalts, a mixed ſalt is produced which chemiſts have called *Salt Alembroth*. See this word.

Sal ammoniac is employed advantageouſly in many arts. It is particularly uſeful in the tinning of copper and iron. *See* TINNING. It is alſo employed in the fuſion of gold; becauſe it has been obſerved to exalt and heighten the color of that metal.

If ſal ammoniac be treated with nitre in a crucible, and with a red heat, the nitre is obſerved to deflagrate to a certain point. This phenomenon proceeds

from the inflammable matter which enters into the composition of the volatile alkali, which is the basis of the sal ammoniac. It is also this same inflammable principle which produces the good effects of sal ammoniac in the tinning of metals.

Sal ammoniac is found ready formed in volcanos, or in their neighbourhood. It is called *native sal ammoniac*; but it is in too small quantity to furnish the demands of artists. The sal ammoniac sold in commerce is made in great manufactories for this purpose.

The method of manufacturing sal ammoniac was long unknown. Mr. Le Maire and Mr. Granger were the first who explained the process, in very circumstantial memoirs upon this subject communicated to the Academy of Sciences. An extract of these memoirs may be found in Mr. Macquer's Elements of Practical Chemistry; for which reason, we will only briefly mention, that in Egypt, where most of the sal ammoniac is made which is in commerce, soot is employed for this purpose, which is produced by burning the dung of cows and camels, which are the ordinary fuels of that country. This soot is put into large glass vessels arranged near each other in oblong furnaces. The fire is raised gradually, that all the volatile principles of the soot may be driven off; then the fire is encreased towards the end, by which the sal ammoniac is sublimed, the materials of which were contained in the soot; the glass vessels are then broken to get out the loaves of sal ammoniac, which are formed upon the upper interior parts of the glass vessels. These loaves or cakes, as they are found at the shops of druggists, weigh from three to five or six pounds. They are more or less blackened by a quantity of fuliginous or sooty matter, which rises with the sal ammoniac in the sublimation. *See* Soot.

Sal ammoniac may be purified from this extraneous matter by the means commonly employed for the purification of salts, that is, by dissolving in water, filtrating, crystallizing, and by subliming a second time, if this should be thought necessary: a sal ammoniac is then obtained perfectly white and pure. Sal ammoniac may be made by combining marine acid to the point of saturation with volatile alkali, obtained from the distillation of animal or vegetable substances, and by filtrating, crystallizing, and subliming the saline matters thus combined. But this sal ammoniac would cost more than the price it is generally sold for. Although the volatile alkali used for this process, solid or liquid, be very impure and impregnated with much empyreumatic oil, from which it is difficult to purify it, yet the sal ammoniac obtained from it by this method is very pure and good; because the volatile alkali, when it combines with an acid, separates itself from all the superabundant oil with which it was at first combined: hence the volatile alkali obtained by decomposing sal ammoniac is better disengaged from all superabundant oily matter than what is obtained by any other method. But we must observe, that the volatile alkali obtained from sal ammoniac always carries off with it some of the substance employed for the decomposition. This circumstance must produce different effects in chemical experiments, to which attention ought to be given. (*q*)

(*q*) To the above article we shall add; 1. Sal ammoniac requires four times its quantity of water to dissolve in that liquid. 2. Its volatility is diminished so much by repeated sublimations, that it remains half fluid at the bottom of the subliming vessel; and when sal ammoniac was repeatedly sublimed together with mercury corrosive sublimate,

LII. AMMONIACAL SALT (VITRIOLIC). This is a neutral salt composed of vitriolic acid saturated by volatile alkali.

This salt may be made by several different methods.

1. By combining vitriolic acid with disengaged volatile alkali.

2. By decomposing sal ammoniac by vitriolic acid in Glauber's manner. If this latter method be used, a marine acid is obtained by distillation, strong in proportion to the concentration of the vitriolic acid employed; and in the retort the vitriolic ammoniacal salt remains, which *Glauber* called his *secret sal ammoniac.*

3. By decomposing all vitriolic salts with earthy or metallic bases, by means of volatile alkali. *See* ALKALI (VOLATILE).

This salt has the properties of sal ammoniac, with the differences depending on their different acids. It is semi-volatile; it may be entirely sublimed; it cannot be decomposed in close vessels without some intermediate substance; it has a sharp taste; it easily dissolves in water; and is susceptible of crystallization. This ammoniacal salt is not used in arts or in medicine. Glauber attributes many wonderful properties to it, which it certainly does not, so eminently at least, possess.

LIII. AMMONIAC SALT (NITROUS). This salt is composed of nitrous acid saturated with volatile alkali. It is found in earths, or plasters where nitrous acid is generated, when these earths have imbibed a sufficient quantity of putrid animal or vegetable substances to furnish volatile alkali to the generating nitrous acid.

Nitrous ammoniacal salt may be made, as the vitriolic, by three methods:

1. By combining to the point of saturation nitrous acid with volatile alkali.

2. By decomposing sal ammoniac by means of nitrous acid.

3. By decomposing nitrous salts with earthy or metallic bases, by means of volatile alkali. *See* ALKALI (VOLATILE).

Nitrous ammoniacal salt has a very pungent taste; is soluble in water; capable of forming beautiful needle-like crystals, like those of ordinary nitre.

This salt has the singular property of detonating alone, when exposed to a certain degree of heat, and without the necessity of addition, as in ordinary nitre, of inflammable matter. It seems even to inflame with less heat than nitre mixed with inflammable matter does.

This property proceeds from the phlogiston or inflammable matter which enters as a principle into the composition of the volatile alkaline basis of this salt. This property also furnishes a decisive proof of the existence of this inflammable matter in volatile alkali.

This inflammability of nitrous ammoniacal salt renders it incapable of sublimation, like the other ammoniacal salts, as an explosion would certainly happen

mate, and the residuum of each preceding operation mixed with the sublimed salt, the whole matter became quite fixed in the fire, and would no longer rise from the bottom of the glass. *Neuman.* 3. The degree of heat necessary to volatilize sal ammoniac is a little below that of ignition, nearly the same with which lead is melted. 4. Pott says, that a small quantity of sal ammoniac may be produced by distilling sea-salt with charcoal or with alum, or by distilling marine acid with Armenian bole. 5. The same author affirms, that the inflammability of sulphur is destroyed by subliming it with twice its quantity of sal ammoniac.

in the operation. Chemiſts do not ſeem to have examined particularly the properties of this ſalt; neither is it uſed in arts or in medicine. If this curious ſalt were to be more particularly examined, the operator would need the greateſt circumſpection to avoid exploſions.

LIV. AMMONIACAL SALT (VEGETABLE). This name is given to all neutral ſalts formed by combinations of volatile alkali with vegetable acids. But theſe ſalts are hitherto little known, although they deſerve to be examined. That ſaline combination formed by volatile alkali and vinegar is called *Spirit of Mindererus*.

LV. AMMONIACAL SALT (ANIMAL). As the fat of animals contains much acid, (*See* FAT) an ammoniacal ſalt might be formed by combining this acid with volatile alkali, which might be properly called animal ammoniacal ſalt. But this combination has not yet been made, or examined.

Laſtly, the phoſphoric ſalt, or native ſalt of urine, belongs to the claſs of ammoniacal ſalts; and as its acid appears to be peculiarly animal, it would alſo be in this ſenſe a true animal ammoniacal ſalt. *See* SALT (FUSIBLE) *of* URINE.

LVI. AMMMONIAC (FIXED). *(r)*

LVII. AMMONIAC (GUM). *(s)*

LVIII. AMETHYST. (*t*)

LIX. AMIANTHUS.) *(u)*

LX. ANALYSIS. Chemiſts underſtand by the word analyſis, the decompoſition of a body, or the ſeparation of the principles and conſtituent parts of a compound ſubſtance.

Chemiſtry furniſhes ſeveral means for the decompoſition of bodies. Theſe means are all founded on the differences of the properties belonging to the different principles of which the body to be analyſed is compoſed. Thus, for example. if a body be compoſed of ſeveral principles, ſome of which have a great, and others a moderate degree of volatility, and, laſtly, others are fixed, its moſt volatile parts may be firſt ſeparated, by a graduated heat, in diſtilling veſſels, and then the parts which are next in volatility will paſs over in diſtillation; and laſtly, thoſe parts which are fixed, and capable of reſiſting the action of fire, will remain at the bottom of the veſſel. As this analyſis cannot be made but by means of fire, it is called the *Analyſis by fire*.

(r) FIXED AMMONIAC is a name given to the reſiduum formed by decompoſing ſal ammoniac with a calcareous earth. It is a ſalt compoſed of that earth and marine acid. *See* SALT (MARINE) *with* BASIS *of* CALCAREOUS EARTH.

(*s*) GUM AMMONIAC is a gum reſin, from an ounce of which ſix drams may be diſſolved by ſpirit of wine, or ſix drams two ſcruples and a half may be diſſolved by water. *Neuman*.

(*t*) AMETHYST. This is a violet-colored, frequently yellowiſh or reddiſh, pellucid gem, the ſeventh in degree of hardneſs from diamonds, fuſible by fire, which alſo deſtroys its color. It is found amongſt quartz, and is probably only a colored quartz cryſtal. This ſtone may be imitated by adding to a fritt of cryſtal-glaſs eight parts of magneſia and one part of zaffre.

(*u*) AMIANTHUS is the lighteſt and ſofteſt of all ſtones. It conſiſts of fibres parallel or interwove, ſo flexible, that cloth has been formed of them. By a ſtrong heat it is whitened, hardened ſo as to be capable of ſtriking fire with ſteel, and rendered brittle. It has generally been conſidered as unfuſible by fire; but Mr. D'Arcet, in a Memoir of the French Academy for the year 1766, affirms, that by a violent and long continued fire it is fuſible, and that it forms a black glaſs. This ſtone is inſoluble by acids.

It

It is proper to obſerve, that this method of analyſing does not ſucceed equally well upon all bodies, and that it is very imperfect upon ſome bodies, which being compoſed of principles of very different degrees of volatility, might ſeem well adapted to it. This particularly happens when the principles of ſubſtances analyſed by this method have a great adheſion with each other; becauſe in this caſe a volatile principle drags along with it a portion of the fixed principle, which would never have been raiſed by the degree of heat employed without this adheſion, and as it were, participation of the volatility of the former to the latter. Frequently, therefore, the principles obtained by this method of analyſis are in part ſtill united with each other, and are far from the proper degree of purity. In this caſe it is neceſſary to have recourſe to new diſtillations, rectifications, and purifications, to obtain them ſufficiently pure and ſeparated from each other. This inconvenience particularly attends the analyſes by fire of moſt animal and vegetable ſubſtances, in which analyſes very volatile acids and alkalis are often procured, ſtill united with much ſuperfluous heavy oil. The beſt method of avoiding this inconvenience, or at leaſt of diminiſhing it as much as poſſible, is to manage very careſully the fire; for it is evident that a too ſtrong fire would readily confound all the principles of the ſubſtance to be analyſed.

A ſecond no leſs important remark concerning the analyſis by fire, is, that by this method the *proximate principles* of very compound bodies, ſuch as moſt vegetables, cannot be obtained; becauſe theſe proximate principles being themſelves very compound, and of a delicate mixture, cannot, for the moſt part, ſupport the action of fire without a total or partial decompoſition; or, at leaſt, without receiving ſuch conſiderable alterations that they can no longer be known. This inconvenience chiefly attends thoſe proximate principles which are not poſſeſſed of great volatility, as we may ſee from the example of mild and fat oils, of gummy, reſinous, ſaponaceous, and extractive parts of vegetables. Theſe principles cannot ever be procured by diſtillation ſuch as they were in the plant.

Theſe inconveniences have induced chemiſts, particularly the modern, to ſearch for other methods of decompoſing bodies, and ſepararing their principles. They have found one method which wonderfully ſupplies in many caſes the defects of the analyſis by fire.

This ſecond method of decompoſing bodies is founded on the different degrees of ſolubility in moſt menſtruums, which the different principles poſſeſs. Thus when a body is compounded of ſeveral ſubſtances; one of which, for inſtance, is ſoluble only by ſpirit of wine, a ſecond is ſoluble only by water, and a third is ſoluble only by ether; theſe ſubſtances may be very eaſily ſeparated from each other, by ſubmitting ſucceſſively the compound body to the action of theſe menſtruums, each of which diſſolves that particular ſubſtance to which it has an affinity, and from which it may be afterwards eaſily ſeparated. This method of analyſis is excellent to ſeparate without any ſenſible alteration the greateſt part of the proximate principles of vegetables, and to obtain them as they exiſt in the plants. If, for inſtance, a vegetable matter contain gum, reſin, and an oil or oily concretion not ſoluble in ſpirit of wine; we may firſt deprive it by water of its mucilaginous and gummy parts, which may afterwards be obtained in their natural ſtate merely by evaporation of the water; then, by applying to this vegetable matter ſpirit of wine, we may extract its reſinous parts; and laſtly, we may

may, by treating it with ether, ſeparate its oily part, which could not be diſſolved the water or the ſpirit of wine. It is afterwards eaſy to obtain the ſubſtances diſſolved by the ether and ſpirit of wine, pure and free from their menſtruums, either by evaporation, or by addition of much water, which ſeparates the oily and reſinous parts. *See* SPIRIT *of* WINE, and ETHER.

As this method of ſeparating the principles of bodies is ſolely founded on the action of menſtruums, this kind of analyſis has been called ANALYSIS *by* MENSTRUUMS.

What has been ſaid on this ſubject is ſufficient to make its great utility appear. We may add, that in ſome caſes this is the only analyſis which can be applied, and by which a perfect and compleat ſeparation can be effected. If, for example, the body to be analyſed conſiſts of two ſubſtances which equally reſiſt the action of fire, as gold and ſilver, it is evident that theſe two ſubſtances cannot be ſeparated from each other but by means of a menſtruum which can only diſſolve one of them. Thus, by expoſing a maſs compoſed of gold and ſilver to aqua regia, which diſſolves the gold only, or to nitrous acid, which diſſolves only the ſilver, the ſeparation of theſe two metals may be effected. The operation called *Parting* ought then to be conſidered as the true analyſis by menſtruums. *See* PARTING.

We may ſay the ſame of all decompoſitions and precipitations which are made in numberleſs chemical operations by intermediate ſubſtances, either by the humid method, or by the dry, in different fuſions. In all theſe caſes, the intermediate ſubſtance employed effects the precipitation or ſeparation of the body intended to be ſeparated, by really diſſolving another body to which the former was united. Thus the analyſis by menſtruums is at leaſt of as extenſive utility as the analyſis by fire, ſince it takes place in almoſt all the operations of chemiſtry.

It is true, that in many caſes the analyſis by menſtruums, as well as that by fire, is incomplete. This inconvenience happens when there is in the compound body to be analyſed ſome intermediate ſubſtance, by means of which the menſtruum is rendered capable of acting upon ſome of the principles, which it ought not to do, in order to have a complete and perfect ſeparation. But theſe inconveniences may be prevented or repaired.

Frequently it is neceſſary, in order to make a perfect analyſis of bodies, to unite theſe two methods by fire and by menſtruums: the one may be made to aſſiſt the other; and from theſe combined means a decompoſition reſults much more perfect, and more accurate, than could have been obtained by either of them ſeparately. If, for inſtance, we intended to ſeparate from ſpirit of wine ſuperabundant quantities of oil and water which are generally united with it, we ought, inſtead of diſtilling it alone, to mix with it ſome fixed akali, or very dry earthy matter, and then to proceed to the diſtillation: theſe alkaline or earthy ſubſtances acting upon the oil and water will retain and fix them; by which means the ſpirit of wine is allowed to riſe much purer in diſtillation.

We ſhall ſay nothing more here upon analyſis in general. This ſubject is ſo extenſive, that to make particular applications of it, we ſhould be obliged to conſider all the objects in chemiſtry. Thoſe who know the uſe of general principles will eaſily apply theſe to particular operations; and longer details would be fatiguing and uſeleſs to others. It is nevertheleſs proper to mention the general

neral articles which are related to this. *See* DECOMPOSITION, DISTILLATION, SUBLIMATION, PRECIPITATION, EXTRACTION, SOLUTION.

LXI. ANGELICA. *(w)*

LXII. ANIMAL. *(x)*

LXIII. ANIME. *(y)*

LXIV. ANISE. *(z)*

LXV. ANNOTTO. *(a)*

LXVI. ANTIMONY. Antimony is a mineral of a metallic, shining, leaden color, the masses of which have no determinate figure, but are composed of long, brittle, parallel needles. It is composed of a semimetallic substance called its *regulus*, united with sulphur, as most metallic substances are in their mineral state.

There are two kinds of antimony, namely, that which is called *native* or *mineral*, and is in the same state as when it is dug out of the earth; and *fused antimony*, so named, because it has been actually fused in order to separate it from adhering stones and earths. This operation, which ought rather to be called liquation than fusion, considering these words in their metallurgic sense, is made in great perfection upon the grounds whence antimony is dug. The process is very simple and easy. It consists in placing the mineral in earthen pots, pierced in their bottoms with small holes. These pots are placed in a furnace, where they receive the necessary heat for the fusion of the antimony. As it is very fusible, (for it melts before it is red) this degree of heat is much less than is necessary for the fusion of the earthy and stony matters mixed with it. The antimony thus melted runs through the holes at the bottom of the pots, and is received in other pots placed below, and defended from the heat as much as is possible. The antimony is allowed to cool and fix in these receivers, from which it therefore takes its form of cakes, in which it is sold. The countries which furnish most antimony are Hungary and Auvergne, whence the names *Hungarian antimony*, and *Auvergne antimony*. Antimony is also found in other countries, and in different forms; upon which subject consult the article ORE *of* ANTIMONY.

(*w*) ANGELICA. The root of this plant contains an essential oil, and a resinous matter. *Neuman.*

(*x*) ANIMAL KINGDOM. *See* KINGDOM.

(*y*) ANIME, according to Neuman, is a resin totally soluble in spirit of wine. It is called improperly *gum anime*. Other authors mention two substances to which this name is given, one of which is brought from India, and is resinous: the other is brought from Brasil, and is similar in appearance and insolubility in spirit of wine, or in water, to the substance called *gum copal*. All the anime which is to be found in shops of druggists is of this latter kind; and if it does not proceed from the same tree as gum copal, is scarcely distinguishable from it.

(*z*) ANISE. The outer thin skin of the seeds of this plant contains an essential oil, and the kernel itself contains an inodorous, insipid, expressible oil. *Neuman.*

(*a*) ANNOTTO is a red mass extracted by infusion in water, and fermentation from the pellicles of the seeds of an American tree. To water this mass gives only a pale brownish-yellow color, and is very little soluble in that liquid.* It readily dissolves in spirit of wine, and gives a bright orange color: hence it is useful as an ingredient in varnishes and lacquers. By alkaline salts it is rendered soluble in water, without any change produced upon its color. Wool and silk boiled in this solution acquire a deep, but not durable orange dye. Its color is not changed by alum or by acids; but is discharged by soaps, and is destroyed by exposure to air. It is said to be an antidote to the poisonous juice of manioc, or cassava.

As

As many remedies of great conſequence are prepared from antimony, and as alchemiſts have ſuppoſed it eſſential to the *great work*, a very great number of chemical operations have been made upon this mineral, the reſults of which are diſtinguiſhed by particular names. We ſhall here give a ſummary account of theſe operations, and ſhall make references for the particular details and explanations.

The metallic part of antimony is diſengaged from its ſulphur by ſeveral methods. The firſt and ſimpleſt is torrefaction, commonly called *Calcination of Antimony*. It conſiſts in expoſing crude antimony, groſly powdered, in a flat and ſhallow earthen veſſel, to the action of a moderate fire, taking care to ſtir it conſtantly. During this calcination, the ſulphur, being leſs fixed than the metalline part, is gradually evaporated. The calcination is continued till no more ſulphureous vapors riſe. What remains after the calcination is the metallic part of the antimony ſeparated from the mineral ſulphur, and even deprived of part of its own inflammable principle. This ſubſtance is much more fixed and leſs fuſible than antimony, becauſe in general metallic earths are ſo much more fixed and leſs fuſible as they are deprived of more of their inflammable principle. It is called *Calx of Antimony*. It is of a grey aſh color. When taken internally it is violently emetic and purgative, which antimony is not, becauſe its metallic earth is inveloped by ſulphur, and thereby deprived of moſt of its properties.

Calx of antimony, expoſed to a great heat in a crucible, melts, and appears when cold a hard, compact, brittle, ſhining maſs. This melted matter is ſometimes tranſparent, and of a more or leſs deep hyacinthine color. It is then called *Glaſs of Antimony*, becauſe it has the appearance and properties of a vitrified ſubſtance.

Sometimes calx of antimony, when fuſed and cooled, becomes an opake brown maſs. It is then called *Liver of Antimony*.

Theſe differences proceed from the greater or leſs quantity of inflammable principle which remains united with the metallic earth of the antimony. They conſequently depend on the length and accuracy of the calcination.

When this calcination has been ſlight, and much inflammable matter remains united with the earth of antimony, then the calx produced is capable of melting with leſs heat, and the reſult is liver of antimony, which ought to be conſidered as an intermediate matter betwixt the vitrified and metallic ſtates.

If the calcination has been more compleat, the calx is of more difficult fuſion, and the reſult from it is a vitrified ſubſtance.

Laſtly, if the calcination has been as perfect as is poſſible, the remaining calx is ſtill more refractory, and is even incapable of fuſion and vitrification.

The calx, the liver, and the glaſs of antimony, are violently emetic. The phenomena which they ſhew when treated with chemical agents, are ſo much more ſimilar to thoſe exhibited by the regulus of antimony, as they approach more to the reguline ſtate, that is to ſay, as they are more perfectly deprived of mineral ſulphur, and leſs deprived of their inflammable principle.

Theſe three preparations of antimony being treated in cloſe veſſels, and fuſed with matters capable of furniſhing phlogiſton, ſuch as the black flux, are reduced not into antimony as they were originally, but into a ſemi-metallic, hard, brittl

brittle ſubſtance, of a dull white color, and compoſed of ſhining facets. This ſubſtance is called *Regulus of Antimony*. The cauſe of this change is, that by calcination this mineral is deprived of all the ſulphur which is found united with its ſemi-metallic or reguline ſubſtance, and that this ſulphur is not reſtored to it in the reduction above-mentioned. If then it be intended to reſtore the properties of antimony to its calx, liver, glaſs, or regulus, it ought to be combined by fuſion not only with phlogiſton, but alſo with a proper quantity of mineral ſulphur.

Antimony may be diſengaged from its ſulphur, and at the ſame time reduced either into regulus, liver, or white calx entirely deprived of its phlogiſton, by ſeveral other proceſſes, much ſhorter and more expeditious than calcination, which is always very long.

If a mixture of four parts of crude antimony pulveriſed, three parts of tartar, and one part and a half of nitre, be projected at different times into a large red-hot crucible, and ſurrounded with burning coals; and when the detonation is finiſhed, the fire raiſed ſo as the matter ſhall be fuſed; then upon breaking the crucible when cool, a maſs is found conſiſting of two diſtinct ſubſtances, and which may be ſeparated from each other by the ſtroke of a hammer. The lower ſubſtance is the reguline metallic part, and is called *Regulus of Antimony*. The ſubſtance lying above this is called *Scoria of the Regulus of Antimony*. This ſcoria is alkaline and acrid: it attracts the moiſture of the air, and is compoſed, 1. Of the alkalis of the nitre and of the tartar alkaliſed by each other in the operation; 2. Of a portion of the ſulphur of the antimony, which during the operation united with the alkali and formed a liver of ſulphur; 3. A portion of reguline ſubſtance of antimony diſſolved by this liver of ſulphur; 4. Laſtly, ſome vitriolated tartar which was formed by a part of the acid of the ſulphur combining during the detonation with the fixed alkali.

From the ſolution of the ſcoria of the regulus of antimony in water, a yellow reddiſh matter is depoſited in a certain time, which is nothing elſe than a part of the ſulphur and of the regulus of antimony which quit the alkali without ſeparating from each other; conſequently it is a kind of *Kermes*. When the ſolution of this ſcoria is ſaturated with any acid, a pretty large quantity of reddiſh matter is precipitated, which is compoſed, like the former, of ſulphur and reguline parts. This matter is called SULPHUR (GOLDEN) *of* ANTIMONY, *which ſee*.

Theſe two precipitates, and particularly the latter, are very emetic, although in them the reguline part is, as in antimony, which has no emetic quality, united with a large portion of ſulphur. The true reaſon of this difference is, that in crude antimony the ſulphur is much more intimately and ſtrongly united to the ſemi-metallic part than it is in the golden ſulphur.

Moſt metals, as iron, copper, tin, lead, and ſilver, have a greater affinity to ſulphur than the regulus of antimony has. Hence this regulus may be precipitated in fuſion, and its ſulphur may be ſeparated by means of theſe metals. The regulus thus obtained is called the *Regulus of the Metals*. The name of the particular metal employed to make this precipitation is added. Thus it is called, the *Regulus of Tin*, the *Regulus of Copper*, the *Martial Regulus*, according

ing to the metal ufed in the operation. Iron is moft frequently employed to make this regulus, becaufe of all metals it has the greateft affinity to fulphur, and for that reafon feparates moft eafily and perfectly the reguline part. *See* REGULUS *of* ANTIMONY (MARTIAL).

If inftead of detonating antimony with a fufficient proportion of nitre to obtain the regulus, equal parts of thefe two fubftances are employed; then, after the detonation, no regulus will be found at the bottom of the crucible, but a brown, opake, brittle mafs, of no metallic appearance; in a word, fimilar to that mafs which is obtained by melting the calx of antimony alone, when too little dephlogifticated to be capable of vitrification. This mafs is, properly fpeaking, the fubftance called *Liver of Antimony*, from its color, which fomewhat refembles that of the liver of animals. By this procefs the liver is always made in fmall chemical laboratories. But it is faid that in Holland, where many chemical operations are objects of manufacture, the liver of antimony is made by melting the calx of this mineral alone, fufficiently dephlogifticated. The liver of antimony prepared by either of thefe methods is a violent emetic and purgative. Several difpenfatories require it to be employed in the preparation of *emetic tartar*. *See this word.* It is alfo ufed to purge horfes.

When in this operation of liver of antimony by nitre, the matter has been well fufed, it is obfervable that the mafs found upon breaking the crucible is compofed of two diftinct fubftances. The liver of antimony, being the heavier of the two, is at the bottom; and above it lies a lighter and more faline matter, called the *fcoria*, which may be feparated by a hammer. This fcoria is nearly of the fame nature as that of the ordinary regulus. It is very acrid and alkaline, and contains vitriolated tartar, and liver of fulphur, by which fome liver of antimony is kept diffolved. A golden fulphur of antimony may be alfo precipitated from this fcoria by any acid.

When in the operation of the liver of antimony, the fufion has not been fufficient, or the mixture has been cooled too fuddenly, then the fcoria remains mixed with the liver of antimony, which it in fome meafure keeps diffolved.

Laftly, in detonating antimony with thrice its weight of nitre, after the operation, a mafs perfectly white and void of color is found. This mafs is a mixture of calx of antimony with certain faline matters. Thefe are, 1. Nitre alkalifed by the phlogifton of the fulphur, and of the regulus of antimony; 2. Vitriolated tartar, proceeding from a portion of the acid of the fulphur, combined with the alkali of the nitre; 3. A portion of nitre undecompofed.

As to the calx of antimony obtained by this operation, it is perfectly white, becaufe entirely deprived by nitre not only of all the mineral fulphur, but alfo of its own phlogifton.

This calx well wafhed, fo as to be cleanfed from the falts, is called *Diaphoretic Mineral*, *Diaphoretic Antimony*, and *White Calx of Antimony*. It is neither emetic nor purgative; for which reafon a diaphoretic quality has been attributed to it.

The white calx of antimony is not foluble in acids. It is exceedingly fixed, and often refractory, being capable of fuftaining the greateft violence of fire without vitrifying or melting. All thefe properties, fo different from thofe of the

the regulus, the liver, and the glass of antimony, proceed from its being entirely divested of phlogiston by nitre.

The quantity of nitre employed in this operation is more than sufficient to dephlogisticate entirely all the earth of the antimony, since in the scoria is found some nitre undecomposed, because there was not phlogiston enough in the antimony for that purpose.

These phenomena of the calcination of antimony, which are conformable to those of all other metallic calcinations, prove in a satisfactory manner, that metallic matters owe their volatility, their fusibility, and their solubility in acids to their phlogiston.

The mass remaining in the crucible after the detonation, in the operation of diaphoretic antimony, and which consequently contains the calx of antimony and the salts resulting from the operation, receives aperitive, and even purgative qualities from the salts contained in it. It is called *Unwashed Diaphoretic.* It forms also the substance called the *Flux of Rotrou.*

When the result from the detonation of diaphoretic antimony is washed, in order to cleanse it from the salts, the water dissolves not only the saline matters, but also the finest part of the calx of antimony adhering to these salts. This matter separates and precipitates in form of a very white and fine powder; for which reason it has been called *Pearl-Matter.* It has also been named the *Ceruss of Antimony*, and very improperly the *Fixed Sulphur of Antimony.* For it is evident from the nature of the operation, that no sulphur can remain in it, nor even any inflammable matter. The pearl matter also gives no marks of sulphur contained, and has absolutely the same properties as diaphoretic antimony; and if it differs in any thing, it is in being more perfectly calcined.

The white calx of antimony and the pearl-matter may be reduced into regulus by fusion in close vessels, with a reducing flux, as black flux, but only in part, and with considerable loss.

In all these operations, where antimony is exposed to a fusing heat, a considerable quantity of volatile matter rises in smoke, and adheres in form of a meal or fine powder to any cold body it meets. This is called *Flowers of Antimony*, which are nothing else than the semi-metallic part of the antimony, more or less deprived of the sulphur and phlogiston; but never entirely of the latter: for which reason, they are violently emetic.

In the chemical operations for procuring these flowers, only antimony itself or its regulus are employed. For this purpose a convenient apparatus and vessels are used. *See* FLOWERS *of* ANTIMONY, and FLOWERS *of* REGULUS *of* ANTIMONY.

When crude antimony is boiled in a lixivium of fixed alkali, a liver of sulphur is formed from the combination of this alkali with the sulphur of the antimony, by which the metalline part of the antimony is dissolved. But the alkali, by its being dissolved in water, having but a slight union with the sulphur, this antimoniated liver of sulphur cannot be kept suspended in the water, when the heat of that fluid is less, or much less than is sufficient to make it boil. Hence when the liquor cools, it becomes turbid; and a brick-colored sediment falls down, which has been called *Kermes Mineral.* This precipitate drags down along with it, according to a general rule of all precipi-

tates. a portion of the alkali by which it was kept diſſolved. But this portion of alkali is very ſmall. For this reaſon alſo the kermes cannot be kept diſſolved but in very hot water. Hence it appears that kermes is nothing but an antimoniated liver of ſulphur, containing the ſmalleſt poſſible quantity of alkali, or a ſuperabundant quantity of ſulphur and regulus of antimony.

Kermes may alſo be made by fuſion, that is, by melting in a crucible dry alkaline ſalt and crude antimony, and then diſſolving the combination in boiling water. The ſame phenomena appear, as in the preceding operation, and for the ſame reaſons.

Kermes is a preparation of great utility and importance in medicine. *See the details, the preparation of Kermes, and the theory of it more extenſively, as well as its medicinal virtues, at the article* KERMES MINERAL.

Acids difficultly diſſolve regulus of antimony. To diſſolve it by the vitriolic acid, the ſame proceſs muſt be uſed as in the ſolution of mercury by this acid for the preparation of turbith mineral: that is, to employ a very concentrated acid, and to diſtill in cloſe veſſels. The ſame phenomena alſo occur in this operation as in that for turbith mineral: a very ſuffocating ſulphureous acid riſes; and as Mr. Geoffroy obſerves, a true ſulphur ſublimes, and adheres to the neck of the retort: a white ſaline tumefied maſs remains in the veſſel. When the veſſels are unluted, a white fume iſſues like the ſmoking ſpirit of Libavius. Theſe phenomena of the production of volatile ſulphureous acid, and of concrete ſulphur, are evidently effects of the combination of the vitriolic acid with the phlogiſton of the regulus of antimony.

The nitrous acid does, properly ſpeaking, only corrode and dephlogiſticate the regulus of antimony, which it converts into a white calx. It diſſolves a little better this reguline part, when it is applied to the antimony itſelf. This ſolution, as Mr Geoffroy obſerves, acquires a blueiſh greeniſh color. When only a ſufficient quantity of acid is employed, it may be ſeen to inſert i ſelf betwixt the ſtriæ of the antimony, and there form ſmall cryſtals.

Marine acid does not ſenſibly act upon antimony nor its regulus. It only detaches from the antimony, in lumps, ſome light and ſulphureous flocks.

Aqua regia moſt directly and completely diſſolves regulus of antimony. For this operation, it is proper to employ an aqua regia compoſed of four parts of ſpirit of nitre, and one part of ſpirit of ſalt. This menſtruum is digeſted in a ſand-bath with a gentle heat upon bits of regulus of antimony, which are added ſucceſſively, ſo that one ſhall not be added till the former are diſſolved. By means of this management, directed by Mr Geoffroy in the Memoirs of the Academy of Sciences, aqua regia can diſſolve about a ſixteenth part of its weight of regulus of antimony. This ſolution has a beautiful golden color, which diſappears by the evaporation of white fumes continually riſing from it.

The aqua regia above deſcribed is alſo very proper to diſſolve the reguline part of crude antimony, and the ſolution even ſucceeds better in this way. This is applicable to all the ſolvents of the regulus of antimony.

The combination of marine acid with regulus of antimony, which ſucceeds ſo ill by applying this acid directly to the ſemi-metal, may be much better

made

made by employing a marine acid previously combined with mercury in corrosive sublimate.

When regulus of antimony or powdered crude antimony is mixed with corrosive sublimate, and this mixture distilled, the marine acid, having a stronger affinity with regulus of antimony than with mercury, quits the latter metallic substance to unite with the former; and from this a combination results which passes in distillation, and has a butyraceous appearance. It is a very corrosive metallic salt, and is called the *Butter of Antimony.*

When the regulus is employed to make the butter of antimony, the mercury is separated from the acid of the corrosive sublimate, and passes over in its metallic and fluid state towards the end of the operation, and when the fire is encreased.

But if antimony has been employed to make this butter, a cinnabar may be sublimed, by increasing the fire after the butter of antimony has passed over in distillation. This cinnabar results from the union of the sulphur of the antimony with the mercury, and is called *Cinnabar of Antimony.* *See* BUTTER *and* CINNABAR *of* ANTIMONY.

Butter of antimony is then the result of a combination of the metallic part of antimony with marine acid in its highest degree of concentration, and is therefore a powerful caustic. It may be rendered liquid by a small quantity of water; but if diluted with much water, then the greatest part of the regulus separates from the menstruum, and precipitates in the state of a white powder, which has been called *Powder of Algaroth*, and *Mercury of Life. See these words.*

The powder of algaroth is a very violent emetic. Mr. Beaumé has ascertained, by very accurate experiments, that when it is sufficiently washed it does not retain a particle of marine acid.

The liquor in which the powder of algaroth is precipitated contains all the marine acid of the butter of antimony, with a portion of the reguline part, which may be separated from it by precipitation with an alkali. This liquor has been named *Philosophical Spirit of Vitriol*; which name is improper, since it contains no vitriolic acid.

Nitrous acid poured upon butter of antimony dissolves it easily, and even violently. When this solution has been made gradually and cautiously, a transparent solution is obtained, impregnated with much regulus of antimony.

As in this operation the added nitrous acid forms with the marine acid, already united with the regulus in the butter of antimony, an aqua regia; and as aqua regia is the best solvent of this semi metallic substance, a new solution takes place by the addition of this nitrous acid, entirely similar, as to its concomitant phenomena, to the solutions of metals by this acid, not previously dissolved by any other. This new solution is even so impetuous, that when the quantity of matter is considerable, it is apt to be thrown violently out of the containing vessels.

Butter of antimony is entirely changed by its union with nitrous acid. This acid, as is usual, seizes upon the inflammable part of the regulus of antimony which the marine had left unchanged: it diminishes the adhesion of the marine acid with the regulus. Hence it happens that this new combination of regulus of

of antimony with the acids of aqua regia, when dried and calcined, no longer possesses the volatility of the butter of antimony. Instead then of subliming or passing in distillation without decomposition, as the butter does, the new compound resists the action of fire, is decomposed, lets its acids escape, and remains in the state of a white powder.

If fresh nitrous acid be twice poured upon this white powder, and each time the matter evaporated and calcined, the regulus of antimony is then reduced to a white earthy substance, indissoluble in the nitrous acid, entirely fixed and unfusible, and possessed of no emetic or purgative qualities. This preparation has been called *Bezoar mineral*. See *this word*.

This operation is one of those which proves most sensibly the power of the nitrous acid to calcine metallic substances, by depriving them of their phlogiston. It also proves that it is chiefly by means of this phlogiston that the nitrous acid dissolves these substances, since it cannot dissolve bezoar mineral, diaphoretic antimony, nor any other similarly dephlogisticated metallic substances.

LXVII. ANNEAL. Annealing consists in making metals red-hot which have become hard and stiff by frequent percussion, or by a strong compression, in order to restore their former malleability and tractability. All metals have the singular property of becoming more or less hard, untractable, and unmalleable, after they have been struck some time with a hammer. It seems as if something happened to them similar to the effect produced by the tempering of steel. Metals thus affected become more elastic than before, but, at the same time, more brittle. They are more sensibly affected in this manner in proportion as they are naturally harder. Copper is so much affected, and even gold and silver, by hammering, that they soon cease to be malleable, and are apt to split and crack, instead of being extended, under the hammer. This labor therefore must be often interrupted, to soften and restore malleability to metals. This is effected by making them red-hot, which the workmen call *annealing*. Thus heat produces the same effect on metals in the state described, as it does upon tempered steel: for if the hardest tempered steel be made red-hot, and cooled slowly, it becomes as tractable and ductile as the softest iron.

There is also an annealing for works made of glass. It consists in placing them, while newly made and still hot, in an oven or furnace, where they very slowly cool. This annealing for bottles and other glass utensils is quite necessary to render them serviceable; for all glass which is cooled suddenly is liable to be broken, not only by the least change of heat and cold, but even by the slightest force.

LXVIII. APYROUS. This word is applied to denote that property of some bodies, by which they resist the most violent fire without any sensible alteration. Apyrous bodies ought to be distinguished from those which are *refractory*. Refractory substances are those which cannot by violent heat be fused, whatever other alteration they may sustain. But a body, properly speaking, apyrous, can neither be fused by heat, nor can undergo any other change. Hence it follows, that all apyrous substances are also refractory, but that every refractory substance is not apyrous. Very pure calcareous stones, for instance, are refractory, because they never melt without addition of other substance: but they are not apyrous; because by fire their weight is considerably diminished, the adhesion of their integrant parts is destroyed, and all their essential properties are changed

changed by their conversion into quicklime. On the contrary, a very clear and pure diamond is apyrous, because the strongest fire is incapable not only of melting it, but also of producing upon it any other sensible alteration; so that a diamond which has been a long time exposed to the most intense heat, is found to be the same in all respects as it was before.

Perhaps there is no body in nature essentially and rigorously apyrous. This too is very probable; but it is sufficient that there be bodies apyrous relatively to the degree of fire which art can produce, to entitle them to that name.

LXIX. AQUA-FORTIS. Aqua-fortis is a name given by artists and manufacturers to nitrous acid, from its dissolving power. As it is not the concentrated and smoking nitrous acid which is employed in the arts, it seems that the name aqua-fortis may be retained by that acid which has not these qualities.

Most artists who use nitrous acid, call the purer and stronger kind, which is also considerably dearer, by the name of *Spirit of Nitre*. For the properties of this acid, *see* ACID (NITROUS); and for the distillation of it, *see* SPIRIT of NITRE.

In the manufacture of soap, the caustic alkaline lixivium is called also the *strong water*, or *soap-lees*, or *lixivium of soap-boilers*. *See* LIXIVIUM.

LXX. AQUA-REGIA. Aqua-regia is a mixture of the nitrous and marine acids. These two acids are mixed to obtain a menstruum capable of acting upon certain bodies which no pure acid can dissolve, or but imperfectly: particularly gold and platina cannot be dissolved in their aggregated state by any other acid than by aqua-regia. Tin and regulus of antimony are better and more easily dissolved by aqua-regia than by any other acid.

This menstruum may be made either by merely mixing the spirit of nitre with spirit of salt, or by dissolving in spirit of nitre a salt containing marine acid, and particularly sal ammoniac and common salt. Lastly, it may be well made by distilling nitrous acid from either of these salts; because nitrous acid, being capable of disengaging marine acid from these salts, does actually disengage it, either by simply dissolving them in nitrous acid, or by distillation.

The only difference betwixt the several sorts of aqua-regia, prepared in these different manners, is, that the aqua-regia made by merely dissolving sal ammoniac or common salt in nitrous acid contains ammoniacal or cubic nitre, and that these neutral salts do not exist in the aqua-regia made by mixture of the two acids, or by distillation.

The presence of these neutral salts in aqua-regia does not injure its dissolving powers. Thus, as the aqua-regia which contains them is the easiest prepared, and least expensive, it is more generally used than the others. But it is necessary to observe, that the ammoniacal nitre in the aqua-regia may occasion considerable differences in the nature of the precipitates made from solutions of metals in this menstruum, by separating from these precipitates any of those metallic substances which it is capable of dissolving, and also by a portion of it adhering to precipitates. For instance, gold precipitated by a fixed alkali from an aqua-regia made by mixing the pure nitrous and marine acids, does not fulminate; whereas it does fulminate when precipitated from an aqua-regia made by dissolving sal ammoniac in nitrous acid. *See* PRECIPITATES; and GOLD (FULMINATING).

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The mixture of the nitrous and marine acids presents a very ſingular and remarkable phenomenon; which is, that the vapors of this mixture are more expanſive and more difficult to be confined than the vapors of either of the acids before mixing. This proves a re-action of theſe acids upon each other. This phenomenon is very little ſenſible when the acids employed contain much ſuperabundant water; but is more manifeſt in proportion as theſe are more concentrated. I have obſerved, that upon mixing moderately ſmoaking nitrous and marine acids, which had remained without occaſioning any diſturbance in their bottles, an aqua-regia has been formed infinitely more ſmoaking, and which has made the ſtopper fly out of the containing bottle, particularly in weather ſomewhat warm. Mr. Beaumé, when diſtilling a pretty ſtrong nitrous acid upon ſal ammoniac, obſerved, that the vapors which paſſed were ſo elaſtic, that notwithſtanding every precaution that could be taken in ſuch a caſe, it was impoſſible to continue the diſtillation.

As to the proportions of nitrous and marine acids, or of ſal ammoniac, which ought to be employed for the preparation of aqua-regia, there are no eſtabliſhed rules. Common aqua-regia is made by diſſolving four ounces of ſal ammoniac in ſixteen ounces of nitrous acid. But theſe proportions ought to be varied according to the nature of the ſolutions intended.

To diſſolve, for example, the greateſt poſſible quantity of platina, the beſt proportion is equal parts of the two acids.

To diſſolve the greateſt quantity of regulus of antimony, the aqua-regia ought to be compoſed of four parts of nitrous acid to one of marine.

In general, the greater the proportion of marine acid, or of ſal ammoniac, is in aqua-regia, the leſs are the imperfect metals, and particularly tin calcined and precipitated by it. An aqua-regia, compoſed of two parts of ſpirit of nitre and one part of ſpirit of ſalt or of ſal ammoniac, makes a clear ſolution of nearly an equal weight of tin, without forming any precipitate: but for this purpoſe, the operation muſt be performed ſlowly, and heat muſt be avoided as much as poſſible. *See* GOLD, PLATINA, TIN, and REGULUS *of* ANTIMONY. *(b)*

LXXI. AQUA-SECUNDA. This is nothing elſe than aqua-fortis diluted with much pure water. It is employed in ſeveral arts to clean the ſurface of metals and of certain ſtones, and for ſome other purpoſes.

LXXII. AQUA-VITÆ. Aqua-vitæ is the ſpirituous part obtained by a firſt diſtillation from wine, or any other liquor which has undergone the vinous fermentation. It is properly ſpeaking, ardent ſpirit, or ſpirit of wine.

To make the aqua-vitæ that is ſold in commerce, wine is put in large copper alembics or ſtills, to which worms are fitted, and the diſtillation is ſo conducted

(b) Aqua-regia does not diſſolve ſilver: but when the quantity of marine acid contained in the aqua-regia is very ſmall, the acid of nitre does then diſſolve ſilver, which is immediately afterwards attacked by the marine acid, with which it forms the metallic ſalt called *luna cornea*, and is precipitated. Aqua-regia diſſolves a larger quantity of lead than marine acid. All the other metals it perfectly diſſolves. According to Gellert's table, the ſubſtances which aqua-regia diſſolves are placed in the following order, beginning with thoſe to which it moſt powerfully unites: Phlogiſton, zinc, iron, regulus of cobalt, copper, tin, arſenic, biſmuth, mercury, lead, regulus of antimony, gold. In this table copper is erroneouſly placed before tin, as the latter metal readily precipitates the former.

that

that the liquor flows out of the beak of the still in a constant stream, and is continued till this liquor begins to be no longer inflammable.

It is evident that this distillation, being hastily and unartfully performed, can only furnish a very impure spirit of wine, mixed with several of the other principles of the wine employed. Thus aqua-vitæ contains much superabundant water, and much oil of wine, substances entirely foreign to what is properly called spirit of wine.

These heterogeneous matters contained in aqua vitæ prevent it from being employed in chemical operations. To purify it, and change it into spirit of wine, it must be again distilled and rectified. *See* SPIRIT *of* WINE.

LXXIII. AQUILA ALBA. (c)

LXXIV. ARBOR DIANÆ. The arbor Dianæ is the result of a chemical operation by which particles of silver, previously dissolved in nitrous acid, are capable of arranging themselves in the form of a shrub. Chemists have called this *Arbor Dianæ*, from the silver which they also call Diana or the Moon. The following process given by Lemeri for making the arbor Dianæ succeeds well:

" Take an ounce of fine silver, dissolve it in a sufficient quantity of spirit of " nitre, very pure and moderately strong; mix this solution of silver in a mat- " trass with about twenty ounces of distilled water; add to this mixture two " ounces of mercury, and let the whole remain at rest. During a space of about " forty days, a kind of silver tree will be formed upon the mercury, with " branches resembling vegetable ramifications."

As this process is very long, we shall here add another much shorter, taken from a memoir of Mr. Homberg, and quoted by Mr. Baron, in his edition of Lemeri's Chemistry.

" Make an amalgam without heat, of four drams of filings of silver, or, still " better, of silver-leaf, and of two drams of mercury (*See* AMALGAM); dis- " solve this amalgam in four ounces, or a sufficient quantity, of spirit of nitre " pure and moderately strong; dilute this solution in about a pound and a half " of distilled water; shake the mixture, and preserve it in a bottle with a glass " stopper: when this preparation is to be used, an ounce of it is to be put into a " phial together with about the size of a pea of an amalgam of gold or of silver, " which ought to be soft as butter; and the whole is to remain at rest: soon " afterwards, small filaments are to be seen issuing from the small amalgam, " which quickly encrease, branch out on both sides, and take the form of " shrubs."

This experiment, which is generally considered merely as curious and amusing, is founded on many of the essential properties of the substances employed. As mercury has a stronger affinity than silver to nitrous acid, it obliges this metal to separate and precipitate. But in this precipitation there are two essential particulars: the first is the color of the silver precipitated, which on this occasion appears in its natural form and metallic brilliancy. The cause of this is, that it was precipitated by a metallic substance; for it appears, that in general this happens whenever one metal is precipitated by another metal; whereas

(c) AQUILA ALBA is a name given to sweet mercury. *See* MERCURY (SWEET).

metals precipitated by any other ſubſtance are always in form of calxes, or earthy precipitates, without any metallic appearance. *See* PRECIPITATION.

The ſecond remark to be made on the precipitation of ſilver in this experiment is, the ſingular arrangement taken by the particles of ſilver on the ſurface of the mercury one after another, according as they are ſeparated from the nitrous acid. We cannot but perceive in this phenomenon a very ſenſible effect of the attraction or affinity of the integrant parts of the ſame ſubſtance, or of two ſimilar ſubſtances to each other. In fact, it can only proceed from this affinity which the particles of ſilver firſt ſeparated from the nitrous acid have with the mercury, that they rather attach themſelves to the ſurface of that metallic ſubſtance, than to any part of the veſſel or of the liquor; and it alſo proceeds from this tendency which the particles of ſilver have to each other, that thoſe which are afterwards ſeparated from the nitrous acid adhere to the particles already attached to the mercury, and to each other, rather than to any other body.

As to the neceſſary conditions for this experiment of the arbor Dianæ, it has been already recommended to employ very pure ſilver, nitrous acid, and water, becauſe the greateſt part of the extraneous matters with which theſe ſubſtances are generally mixed, are capable of precipitating the ſilver, which in the preſent experiment ought not to be ſeparated but by mercury. *See* SILVER, and PARTING.

In the ſecond place, it is abſolutely neceſſary to dilute in much water the ſolution of ſilver; 1. To avoid the formation of cryſtals of ſilver, which might take place if this ſolution was too concentrated, theſe being a cryſtallization of ſilver in a ſaline ſtate, very different from the arbor Dianæ which is required. *See* CRYSTALS *of* SILVER. 2. Becauſe if the ſolution of ſilver was concentrated, the particles of ſilver would be precipitated too faſt, and in too great quantity; by which they would be prevented from applying themſelves regularly to each other, and would be thrown down confuſedly.

In the third place, it is neceſſary that the nitrous acid ſhould be ſaturated with ſilver before it is diluted with water, otherwiſe the unſaturated part of the acid muſt firſt diſſolve its proper quantity of ſilver or mercury, before the precipitation can take place, which would lengthen the experiment ſo much more, as the quantity of water with which the ſolution was diluted was greater.

LXXV. ARCANUM CORALLINUM. This is nothing elſe than *red precipitate*, on which ſpirit of wine has been two or three times burnt, with an intention of rendering it milder. *See* PRECIPITATE (RED).

LXXVI. ARCANUM DUPLICATUM. This Latin name, which ſignifies *the double ſecret*, is one of the moſt generally known ſalts. It is the ſalt compoſed of vitriolic acid united with vegetable fixed alkali, and therefore does not differ from the *Sal de duobus*, and *vitriolated tartar*. *See* TARTAR (VITRIOLATED).

LXXVII. ARCHIL. *(d)*

(d) ARCHIL, ARCHILLA, ROCELLA, or ORSEILLE, is a white moſs which grows in the Canary and Cape de Verd iſlands, and according to Linnæus, on the weſtern coaſt of England. From this plant is prepared by grinding and moiſtening with volatile alkali, a beautiful purple dye, which is not durable, but is chiefly uſed to give a bloom as it is called,

LXXVIII. ARGENTUM MUSIVUM. (e)

LXXIX. ARRACK. (f)

LXXX. ARSENIC. Arsenic, or *white arsenic*, is, properly speaking, nothing but the flowers or calx of regulus of arsenic.

This substance has singular properties, which render it the only one of its kind.

It is at once a metallic earth and a saline substance. It resembles all metallic calxes in its capacity of combining with phlogiston, and of being thereby changed into a true semimetal.

But it very essentially differs from all metallic calxes and earths.

1. In being constantly volatile; whereas all other calxes of metals, and even of the most volatile semimetals, are very fixed when deprived of phlogiston

2. Metallic calxes, so far from being soluble in water, are even for the most part indissoluble in the strongest acids. White arsenic, on the contrary, is soluble, not only in all acids, but also in water itself, as saline matters are.

According to Mr. Brandt, (*Acta Eruditorum Upsal. de Semimetallis*, 1733) arsenic may be dissolved in fourteen or fifteen times its weight of water, by help of a boiling heat, and transparent yellow crystals may be obtained by evaporating this solution.

3. Metallic calxes, when perfectly calcined, (the calx of the regulus of antimony not excepted) are entirely free from smell, taste, or other action upon the human body. On the contrary, arsenic always preserves a strong alliaceous smell, and when put on the tongue, it excites an impression of acrimony and heat, which produces an involuntary spitting; when taken internally, or even when applied externally, it produces the most terrible and violent effects of a corrosive poison.

4. No kind of earth, nor even the metallic earths, can contract an union with metallic substances. Arsenic easily unites with all metals and semimetals, with the same degrees of affinity that the regulus of antimony does, that is to say, in the order following, according to Mr. Cramer: Iron, copper, tin, lead, silver, gold.

It is proper to observe, that arsenic renders all the metals with which it is united brittle. It renders gold of a greyish color in its broken surface, silver of a deep grey, and copper white. Tin becomes by mixture with arsenic much harder and more unfusible. Lead becomes very hard and very brittle, and it changes iron into a blackish mass. These observations are taken from Mr. Brandt's Memoir quoted above.

called, to other colors. By adding solution of tin to an infusion of archil in water, a durable scarlet dye is produced, as Mr. Hellot says. The color of archil may be extracted by water, by volatile spirits, or by spirit of wine. It loses its color in glass tubes hermetically sealed, and resumes it upon exposure to air. A solution of archil in water gives a permanent and deep stain of a purplish color to marble.

(e) Argentum Musivum or Mosaicum is a mass consisting of silver-like flakes, used for the coloring of plaster figures, and for other purposes, as a pigment. It consists of an amalgam of equal parts of tin, bismuth, and mercury. It is to be mixed with white of eggs, or spirit varnish, and then applied to the intended work, which is afterwards to be burnished.

(f) Arrack is a vinous spirit obtained by distillation in the East-Indies, from rice or sugar, as is said, fermented with the juice of cocoa nuts.

5. The more metallic calxes are deprived of phlogiston, the more unfusible they are rendered. On the contrary, arsenic is always very fusible. Its volatility alone prevents its perfect fusion. It volatilizes, vitrifies, and scorifies all solid bodies, excepting gold, silver, and platina.

6. Earths and metallic calxes have no action upon nitre, which (as is observed under the article *Nitre*) can be decomposed only by phlogiston, by vitriolic acid, and by sedative salt. Arsenic decomposes nitre with the greatest facility, not by combining with and destroying its acid, as phlogiston does; but by disengaging it, and uniting in its place with the alkali, as the vitriolic acid and sedative salt do.

Stahl and Kunkel both knew this property which arsenic possesses of decomposing nitre, and of disengaging its acid.

Stahl directs how to prepare by means of arsenic a very volatile nitrous acid, extremely concentrated, of a penetrating fetid smell, and blue color, although its vapors are red. This color, according to Mr. Beaumé's observation, is caused by the water which must necessarily be put in the receiver to condense the vapors of this very strong and difficultly condensible acid.

Kunkel also directs to make an aqua-fortis similar to that of Stahl, but by a much clearer and simpler process, since he decomposes nitre by arsenic alone; whereas Stahl employs in his mixture a martial vitriol calcined till it becomes red, and does not use pure arsenic, but a combination of equal parts of arsenic with antimony and sulphur, a combination which the chemists have called *Pirmieson*, or *Lapis de tribus*.

These two chemists contented themselves with examining the properties of the spirit of nitre, which they procured by means of arsenic, and nobody had examined the residuum in the retort after distillation.

This matter, being worthy of attention, has been resumed by Mr. Macquer, who has particularly examined the decomposition of nitre in close vessels by arsenic, and the new kind of salt remaining in the retort after the distillation of the nitrous acid.

These researches, the detail of which has been given in two memoirs printed in the collection of the academy, discovered to him that arsenic, by combining with the basis of nitre, after having chased the acid from it, forms with this alkali a kind of salt perfectly neutral, which he has called *neutral arsenical Salt*. *See* SALT (NEUTRAL ARSENICAL).

Another decomposition of nitre by arsenic was known by chemists, and consequently also another combination of arsenic with the basis of nitre, called by some chemists, *Arsenic fixed by Nitre*, or *Nitre fixed by Arsenic*; but this latter combination differs from the arsenical salt of Mr. Macquer in this, that it is not a neutral salt, and that it preserves, on the contrary, all the properties of an alkali. *See* NITRE FIXED *by* ARSENIC.

Mr. Macquer has also made another combination of arsenic with deliquiated fixed alkali. Mention is made of it also under the article *Salt (Neutral Arsenical)*. There the differences are shewn betwixt these two combinations, although formed of the same substances.

White arsenic, although very volatile, is partly fixed by the adhesion which it contracts with different sorts of earths, and even so far as to sustain a vitrifying heat. It facilitates the fusion of many refractory matters; hence it enters into the

composition

composition of several glasses, to which it gives much whiteness and cleanness, nearly in the same manner as borax and the sedative salt do: but it also has the same inconvenience, namely, that glass, in which a considerable portion of arsenic enters, is very quickly corroded by the air.

Dyers employ white arsenic in several of their operations; but the effects it produces are not yet well known, and require a particular examination. Arsenic and its regulus, being capable of combining with all metals, is employed for several metallic compositions; such, for instance, as *white copper*, and *white tombac*. See these words.

Arsenic is employed successfully for making, together with copper and tin, metallic compounds of a beautiful white color, and of a very dense and close texture, and consequently capable of receiving a fine polish, of reflecting well the rays of light, and of being formed into metallic mirrors.

From what has been said concerning the properties of arsenic, we may conjecture that this substance is a metallic earth of a particular nature, intimately combined with a saline and even acid principle, which has never been separated from it by any chemical trial, which accompanies it in its combination with phlogiston when it takes a metallic form, and which adheres to it when, by the burning of this phlogiston, it becomes again white arsenic.

Thus Becker, without having been acquainted with all the properties of white arsenic, gives an idea of it very analogous to this conjecture. He defines it in his *Subterranean Physics*, "a substance composed of the earth of sulphur which "is in common salt," (by which he seems to mean the acid of sea-salt) "and "of a metal joined to it." In another place, he calls it "a coagulated aqua-fortis." And as he imagined he could trace every where his mercurial earth, or at least something mercurial, he calls mercury a fluid arsenic. He considers mercury, and metals precipitated by marine acid, for instance, *luna cornea*, as different kinds of artificial arsenic.

Arsenic combines with sulphur, and forms with it a compound of a yellowish tinge, more or less red according to the quantity of sulphur with which it is united. It is of a beautiful yellow color when the sulphur is only a tenth part of the mixture, and is then called *yellow arsenic*: when the sulphur is a fifth part of the mixture, it is of a very beautiful red color, and it is then called *red arsenic*. The mixture of sulphur renders it a little more fixed and more fusible. Thus red arsenic may be melted, and by this means acquires transparency: it then resembles a ruby, [illegible] or *arsenical ruby*.

All these compounds of arsenic and sulphur are arti[illegible]. They are prepared by mixing and subliming these two substances together in the proportions abovementioned, or, still better, in subliming together the sulphur an[illegible]ic of minerals containing these two substances.

Natural compounds are also found, which are combinations of sulphur and of arsenic, nearly of the same colors as the red and yellow artificial arsenics. They come from the East, from Transylvania, and Turkey. The yellow are called *orpiment*, *orpin*, and *yellow rizagal*: the red are called *sandarach*, *realgar*, or *red rizagal*.

Agricola, Mathiole, Schroder, seem to have confounded the red and yellow artificial arsenics with the native; and after them most chemists and naturalists

have

have also confounded them; a confusion for which they have been reproached by Hoffman, chiefly because he was convinced that native orpiment and realgars are not poisonous, like the yellow and red artificial arsenics, from experiments which he had made on purpose.

On this subject we must remark, that, notwithstanding Hoffman's experiments, which were made only once or twice upon dogs, it would be very imprudent to give the native orpiment or realgars internally: particularly as all chemical trials show that they contain an arsenical principle; and that Hoffman himself agrees, that when they have been exposed to fire, they become very violent poisons.

Hoffman also remarks, that the ancient physicians did not scruple to give internally orpiment and realgar, and justifies them from the reproaches thrown upon them by moderns. But we must observe, that the ancients were unacquainted with white, red, and yellow arsenics, which have been well known only within these two hundred years; and that if they had known the effects of these poisons, and their resemblance to the native orpiments and realgars, they would probably have been less bold. Distrust is as commendable as boldness is blameable in those matters, the almost insensible differences of which may occasion the most troublesome accidents. For this reason, we cannot approve of the singular security with which so great a physician, as Hoffman was, endeavors to inspire a confidence for so suspicious drugs as native orpiment and realgar.

We do not however mean to say, that there is no essential difference betwixt native orpiment and yellow arsenic. It is even agreed that the arsenic contained in the orpiment is better united with the sulphur, and is besides in a less proportion: for one part of orpiment appears to be composed of a sparry stone and mica, from which it receives a foliated and shining form.

When arsenic is combined with sulphur, a part of the sulphur may be separated from it merely by sublimation, because it is more volatile. But some of the sulphur always remains united with the arsenic, from which it cannot be separated but by an intermediate substance.

Fixed alkali and mercury are two intermediate substances proper for this operation.

When fixed alkali is used, it must previously be deliquiated or resolved into a liquid, and with this the sulphurated arsenic is to be made into a paste. This paste is to be sublimed in a proper vessel with a heat gradually raised. The arsenic then sublimes in white flowers. When too much alkali is added, less arsenic is obtained; because some of the arsenic is retained by the part of the alkali which is unsaturated with sulphur. A liver of sulphur is found at the bottom of the vessel after the operation.

When mercury is employed for this separation, it must be triturated and mixed with the sulphurated arsenic, and the mixture sublimed. First the arsenic rises, then cinnabar. All the metallic matters which have a stronger affinity than mercury to sulphur may seem capable of being employed for this purpose; but there are two objections.

1. They have also a considerable affinity with arsenic, and mercury has none.

2. Arsenic

2. Arsenic has the remarkable property of taking from all metallic matters, excepting gold, silver, and mercury, a part of their phlogiston; so that it would be sublimed half regulised.

In the operation by mercury, a part of the cinnabar frequently rises with the arsenic; which makes it necessary to sublime it a second time.

Arsenic is soluble in all acids, and with them forms combinations which have not yet been sufficiently examined. The vitriolic acid has the property of rendering it much more fixed than it naturally is: an effect which it also produces upon mercury.

If a mixture of arsenic and concentrated vitriolic acid be distilled together, a vitriolic acid is obtained, which, as Mr. Macquer observes, has sometimes the exact smell of marine acid. When this solution is distilled till no more acid rises, the retort is then almost red-hot, and no arsenic is sublimed; but it remains fused at the bottom of the retort; and when it is cold, it is found to be one heavy, compact mass, brittle and transparent as crystal-glass. This kind of arsenical glass exposed to the air soon loses its lustre from the moisture it attracts, which dissolves and partly deliquiates it. This deliquium is extremely acid.

Arsenic treated with phlogiston in a proper manner combines with it, and assumes all the properties of a very volatile semi-metal, of a white shining color, more or less upon the grey. This substance is called *Regulus of Arsenic*. *See this word for the manner of making this regulus, and for its properties.*

The arsenic sold in commerce is brought chiefly from the cobalt works in Saxony for making *Zaffre*, and *Smalt*. Cobalt contains much arsenic, which must be separated from it by a long torrefaction, and which would be lost but for a particular contrivance for the collecting it.

For this purpose, cobalt is roasted in a vaulted oven, to which is adjusted a long crooked chimney. The arsenic in vapors passes along this chimney, and is there collected; the arsenic which attaches itself to the coldest and most distant part of the chimney is in form of a white or grey powder, called *Flowers*, or *Meal of Arsenic*; whereas that part of the arsenic which adheres to the hottest part of the chimney, and least remote from the furnace, sustains there a kind of fusion by which it is reduced into compact, heavy, white masses resembling white enamel. These masses of white arsenic are almost always interrupted by yellow or greyish veins and strata. These colors proceed from a little sulphur or phlogiston with which this part of the arsenic is still united.

As arsenic is seldom obtained in the great works entirely free from sulphureous or phlogistical particles, if it be required perfectly pure in operations of chemistry or of arts, it must be again sublimed after mixing it with some intermediate substance capable of absorbing its inflammable parts, such as fixed alkali or absorbent earth.

Arsenic is a very violent corrosive poison: is produces always the most painful symptoms and fatal effects, whether it be taken internally or applied externally. It ought never to be employed medicinally, although some people, not very intelligent, give small doses of it in obstinate intermittent fevers, which it effectually cures, but is always attended with bad consequences to the patients, such as phthisis, and other no less troublesome diseases.

Persons

Perſons poiſoned by arſenic ſuffer acute pains in their bowels, violent vomitings, cold ſweats, ſyncopes, and convulſions, which are always followed by death, unleſs prevented by ſpeedy remedies. The beſt antidotes to this poiſon are large quantities of diluting and ſoftening drinks, as mucilages, oil, milk. Perhaps abſorbent and alkaline matters would alſo produce good effects, from the property which arſenic has of combining with, and in ſome meaſure of being neutralized by, theſe ſubſtances.

When the bodies of perſons killed by arſenic are examined, their ſtomachs and inteſtines are found covered with red, black, livid, inflamed and gangrenous ſpots. Frequently alſo arſenic is found there in ſubſtance, which may eaſily be diſtinguiſhed by its alliaceous ſmell, when put on burning coals, or a red-hot iron.

Mr. Geoffry's table does not ſhew the affinities of arſenic. In Mr. Gellert's they are zinc, iron, copper, tin, lead, ſilver, gold, and regulus of antimony. *(g)*

LXXXI. A S A-FŒ T I D A *(h)*

LXXXII. A S B E S T U S. *(i)*

LXXXIII. A S H E S. This name is generally applied to the ſubſtance remaining of bodies containing an inflammable matter, of which they have been deprived by burning, or calcination in open air. Thus workmen, without underſtanding chemiſtry, and induced merely by analogy or reſemblance, apply

(g) *Neuman* relates that arſenic precipitated almoſt all metallic ſolutions, but moſt of them very ſlowly. Silver, iron, copper, tin, lead, mercury, biſmuth, were precipitated from aqua fortis, and gold from aqua regia. Solutions of mercury corroſive ſublimate, of copper in aqua regia, of zinc in aqua-fortis, and of regulus of antimony ſuffered no precipitation. Solutions in vitriolic acid of zinc and of iron were precipitated, of copper very little. Sugar of lead, and ſolutions of ſulphur with quicklime or fixed alkali were precipitated. The ſame author further relates, that arſenic was not precipitated from its ſolution in vitriolic or nitrous acids by oil of tartar or by volatile alkali, but it was precipitated from marine acid by oil of tartar.

Arſenic is uſed for many purpoſes; by dyers, as an ingredient in compoſitions for ſcarlets and other fine reds; by goldſmiths, for enamelling; by makers of glaſs, for promoting the fuſion of fritt, and the clearneſs and tranſparency of glaſs; by potters, for a white glazing; by eſſayers, in form of glaſs, for promoting the ſcorification of ores which contain tin and antimony, for the preparation of compound metals, and for whitening copper and braſs. *Neuman* ſays, that a beautiful metal like the fineſt ſteel may be made by melting caſt iron with arſenic, glaſs, and a little tin; and that a metal reſembling ſilver may be made from iron, tin, arſenic, and perhaps a little copper. Mr. Brandt (*Act. Upſal.* 1733) propoſes to make a varniſh for ſhips, of arſenic with pitch, ſulphur, or roſin, to preſerve the timber from rotting, and from worms.

(h) ASA-FŒTIDA is a gum-reſin, from four ounces of which rectified ſpirit is capable of extracting two ounces ſix drams and a half of reſinous extract; and water, one ounce three ſcruples and a half of gummy extract. Four ounces of aſa-fœtida, diſtilled either with water or with ſpirit, yielded above a dram of eſſential oil, in which its peculiar ſmell reſides. *Neuman.*

(i) ASBESTUS is a grey, greeniſh or blackiſh ſtone, poſſeſſed of the ſame chemical properties as amianthus, and is therefore referable to the ſame claſs of earths. *See* AMIANTHUS. The chief differences betwixt thoſe two ſtones are, that aſbeſtus is heavier than amianthus, and its fibres are more hard and brittle.

Falſe aſbeſtus is a name given to plume-alum. *See* ALUM (PLUME)

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the name of *ashes* to metallic earths thus calcined. Pewterers, for example, give the name *Tin-ashes*, to the earth of this metal which in fusion has been deprived of its phlogiston and metallic properties. If workmen had always applied names as properly as they have done this, they could not have been blamed. *See* COMBUSTION.

LXXXIV. ASH-HOLE. The ash-hole is the lowest part of a furnace, and is intended to receive the ashes falling from the fire, and to give a passage to the air which is to be introduced into the furnace, to keep up the combustion. *See* FURNACE.

LXXXV. ATHANOR. Chemists have distinguished by this name a furnace so constructed that it can always maintain an equal heat, and which shall last a long time without addition of fresh fuel.

The body of the athanor has nothing in it particular, and is constructed like ordinary furnaces. But at one of its sides, or its middle, there is an upright hollow tower, which communicates with the fire-place by one or more sloping openings. This tower ought to have a lid which exactly closes its upper opening.

When the athanor is to be used, as much lighted coal is put in the fire-place as is judged necessary, and the tower is filled to the top with unlighted fuel. The tower is then to be exactly closed with its lid. As fast as the coal in the fire-place is consumed, that in the tower falls down and supplies its place. As the coal contained in the tower has no free communication with the external air, it cannot burn till it falls into the fire-place.

The athanor being much celebrated and used by ancient chemists, it has been particularly described by many authors, and was formerly found in all laboratories. At present this furnace is much less employed, and is even neglected. The reason of this is, that all the ancient chemists were in search of the art of making gold; and being excited by this powerful desire, and confidence of success, they spared no trouble nor expence to accomplish their design. They undertook without hesitation, operations which required great length of time and unremitted labor. Whereas now, these alluring hopes having vanished, the cultivators of chemistry have no other view than to extend and perfect the theory of this essential part of natural philosophy. This motive, although undoubtedly much nobler than the former, seems however to be less powerful over most men. For now, all long and laborious operations whence chemistry might receive great advantages, are neglected, as being tiresome and disgustful. There is, in fact, a considerable difference betwixt the hope of explaining a philosophical phenomenon, and that of obtaining an ingot of gold capable of producing many others. Hence the instruments employed in long operations, and particularly the athanor, are now much neglected; and also because the fuel in the tower is apt to stick there or fall down at once in too great quantity. The *Lamp-furnace*, which is a true athanor, may be successfully employed in operations which do not require much heat. *See* FURNACE (LAMP). (k)

LXXXVI. AURUM MOSAICUM. (l)

LXXXVII. AZURE. The word azure, which at present signifies in general a fine blue color, was formerly appropriated to *Lapis Lazuli*, called

(k) *See* PLATES.

azure-ſtone, and to the blue prepared from it. But ſince a blue has been extracted from cobalt, cuſtom has applied to it the name of azure, although it differs conſiderably from the former, and is incapable of being uſed for the ſame purpoſes, and particularly for painting in oil. The former at preſent is called *Lapis Lazuli*, or only *lapis*, and the blue prepared from it for painting in oil, is called *Ultramarine*.

The name *azure* is generally applied to the blue glaſs made from the earth of cobalt and vitrifiable matters. This glaſs, which is called *Smalt* when in maſſes, is called azure only when it is reduced to a fine powder. Several kinds of azure are diſtinguiſhed, according to its degrees of beauty, by the names of *Fine Azure*, *Powdered Azure*, and *Azure of Four Fires*. In general, the greater the intenſity of color and the fineneſs of powder, the more beautiful and dear it is. Azure is employed to color ſtarch; hence it has alſo been called *Starch-Blue*. It is uſed for painting with colors and for a blue enamel. *See* Cobalt, Smalt, Zaffre. *See alſo* Lapis Lazuli.

(*l*) Aurum Mosaicum, or Musivum, is a maſs conſiſting of beautiful gold-colored flakes, prepared by amalgamating tin with half its quantity of mercury, mixing this amalgam when cold with half its quantity of ſal ammoniac, and the ſame quantity of flowers of ſulphur, and by expoſing the whole mixture to fire in a matraſs, by which means a ſal ammoniac and cinnabar will be ſublimed, and the reſiduum is the aurum moſaicum, or moſaic gold, weighing about $\frac{1}{3}$ more than the tin originally employed. It is uſed as a pigment and for mixing with glaſs to imitate the ſpangles of lapis lazuli; for which latter purpoſe ſhining talk is alſo employed.

B.

LXXXVIII. BALANCE (HYDROSTATICAL). The hydrostatical balance is an instrument by which the specific gravity of bodies is determined. For this purpose it is necessary to find how much any given weight of a body, whose specific gravity is required, loses of its absolute gravity when plunged into a fluid. All liquid substances are proper to determine specific gravities, because these gravities are only relative: but water has been generally employed for this purpose, because it is the most common liquid, and most constantly of a nearly uniform weight.

When a body is to be weighed in water, it is suspended to one of the arms of a balance, to the other arm of which is fixed an ordinary scale, and in this scale weights are to be put sufficient to maintain an equilibrium with the body suspended in air. The weight necessary for this purpose is to be observed and remembered. Then the same body still suspended at the arm of the balance, and counterpoised by the weights in the scale, is to be immersed in water, by which the equilibrium is destroyed, and the balance inclines to the side of the weights. The weights are therefore to be diminished till an equilibrium is restored with the body sunk entirely in water. The difference betwixt the weights of the same body weighed in air and in water, determines its specific gravity.

It is proper to observe upon this subject, 1. That water can determine the specific gravity of bodies only which are specifically heavier than itself. For it is certain, that if they were lighter than water they could not sink in it by their own weight, which is necessary for the experiment. In this case it is necessary to employ some liquid lighter than water, such as ethereal oils, spirit of wine, or ether.

2. It is proper to remark on the subject of the hydrostatical balance, that it can be employed conveniently for solid bodies only, because the fluids cannot be weighed in water but by means of some vessel which must be immersed along with them. But this vessel having its peculiar specific gravity would render a troublesome calculation necessary. Another method is then generally used to determine the specific gravity of liquids.

3. If the solid body, whose specific gravity is to be determined, be soluble in water, as, for instance, a lump of salt, water could not be employed for this experiment, because a quantity of it would be dissolved during the time of weighing; by which an error would be occasioned so much greater as there was more

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of the ſoluble body diſſolved. In this caſe then it is neceſſary to uſe ſome other liquid which cannot diſſolve the body, or elſe not to employ the hydroſtatical balance, but the ſame method by which the ſpecific gravity of liquids is diſcovered. *See* Gravity, Gravity (Absolute), Gravity (Specific).

LXXXIX. B A L L S (M A R T I A L). Martial Balls are a mixture of filings of iron and of cream of tartar formed into a ſolid conſiſtence and form of a ball, which is uſed to impregnate water or other liquids with iron diſſolved by the tartareous acid. To make theſe balls, one part of filings of iron and two parts of powdered cream of tartar are mixed well together, and put into an earthen or iron veſſel with ſome water. This mixture is to be ſtirred from time to time, till it becomes almoſt dry, and then it is to receive more water, and to be ſtirred as before. This treatment is to be continued till it acquires, when nearly dry, ſomewhat of the conſiſtence and tenacity of ſoftened roſin. Then it is to be rolled up into the form of a ball, which is generally kept tyed up in a rag, and when intended to be uſed, it is to be infuſed in water, till it gives ſome color to that liquid.

The infuſion of martial balls is tonic, vulnerary, diſcutient, and aperitive; and is employed both internally and externally. *See* Iron.

Iron being ſoluble in all acids, is attacked in this preparation by the tartareous acid, which reduces it to a kind of neutral ſalt not cryſtallizable. This ſalt would remain liquid, and would form a *ſoluble martial tartar*, called *Tartariſed Tincture of Mars*. If proper proportions of filings of iron and cream of tartar be uſed, and treated long enough for an entire and complete combination, nothing would be obtained but a liquor or *magma*, which could not be preſerved in a ſolid form, but would be continually moiſt. Therefore in the martial ball there is a good deal of the cream of tartar and filings of iron not combined together, by which its ſolidity is preſerved.

Hence it follows that the infuſion of the martial ball is entirely of the ſame nature as the tartariſed tincture of Mars; and therefore theſe preparations may be ſubſtituted for each other. *See* Tincture *of* Mars (Tartarised).

XC. B A L L S (M E R C U R I A L). Mercurial balls are an amalgam of mercury and tin, ſufficiently ſolid to be moulded, and to preſerve a given form.

The method of making them is, by adding mercury to melted tin, and pouring the fluid maſs into a round and hollow mould.

Theſe balls are employed to purify water, in which they are boiled; for which purpoſe travellers often carry ſome along with them.

XCI. B A L L O O N. This name is given to glaſs bottles, or receivers, which are generally round like hollow ſpheres, or like foot-balls, called in French, *Balons*, whence they are named.

In a laboratory there ought to be balloons of different ſizes, capable of containing from a quart of water to fifteen or twenty pints. The large balloons are employed in diſtillations in great, being capable of containing much, and having necks wide enough to admit thoſe of large retorts. For the contrary reaſons, ſmall balloons are employed when little matter is to be diſtilled.

Large balloons are alſo neceſſary when the vapors diſengaged during the diſtillation are very elaſtic and difficult to be condenſed; becauſe ſuch vapors would not

not find in small vessels sufficient space to circulate and condense; hence they would either burst the vessel, or if a vent was given them to prevent that accident, they would be entirely dissipated and lost. Notwithstanding the size of the balloons employed, so much air is disengaged during the distillation of certain hard bodies, vegetable and animal, such as wood, tartar, hartshorn, &c. and the vapors of certain acids, such as the smoking spirits of nitre and of sea-salt, are so elastic and expansible, that a small hole in the side of the balloon is necessary to give vent to those vapors when necessary; Afterwards this hole, which ought to be about half a line in diameter, is to be closed with a peg of wood, or some lute.

It is to be wished, that in the glass-houses where chemical vessels are made, it was the custom always to make such holes in the balloons; which might easily be done by a pointed instrument, while the glass is still hot and soft. Instead of this practice, chemists are themselves obliged to drill holes through the balloons with considerable difficulty and hazard of breaking. This operation is performed in the following manner.

The most convenient part for drilling this hole is nearer the neck than the bottom of the balloon, and for this purpose one of those bubbles which are always found in glass is chosen.

This bubble is first of all cut or broke by the pointed angle of a flint, and afterwards the hole is to be completed by turning this pointed flint always in the same place. Mr. Beaumé observes, that when an entry is once made by the flint, the hole may be better finished by a triangular drill with a strong hard tempered steel point, because the angular points of the flint are continually breaking, by which the operation is prolonged. (m)

For certain operations balloons with two necks placed opposite to each other are used. One of these ought to be large enough to receive the neck of the retort, and the other to enter the neck of a second balloon. These two joinings must be well luted together. See LUTE.

This apparatus is called *Enfiladed Balloons*. Their use is to encrease the whole space of the receiver, because any number [illegible] be adjusted to each other; and as they communicate with each other, [illegible] capacity is so much larger as their number is greater. But good artists seldom use so troublesome an apparatus. The only one of these vessels which is generally used, is a small oblong balloon with two necks, which is to be luted to the retort and to the great balloon. It serves to remove this receiver from the body of the furnace, and to hinder it from being exposed to too great heat. This small balloon with two necks is called an *Adopter*. As this adopter is larger in its middle than at either extremity, it serves also to receive solid bodies, and to prevent them from passing with the liquids into the great balloon. It is chiefly in distillations of volatile concrete salts that the adopter serves for this last purpose. See DISTILLATION and RECEIVER.

(m) Such pierced balloons, receivers and [illegible] retorts are commonly made in English glass-houses. But as chemists may have occasion to drill holes through glass vessels, we shall [illegible], that this operation may be best performed with a copper drill and emery, as a [illegible] instrument occasions vibrations apt to break the glass.

XCI. BALSAM. By balsams are meant oily, odoriferous, and aromatic matters, liquid, but somewhat thick, which flow spontaneously from certain trees, or from incisions made on purpose to obtain a larger quantity.

These balsams, which may more particularly be called *natural balsams*, to distinguish them from some compositions also called balsams, derive their liquidity and smell from a greater or less quantity of essential oil which they contain, and which may be extracted by distillation with the heat of boiling water. *See* OILS (ESSENTIAL).

Balsams may be even considered as true essential oils, which have lost some of their odoriferous principle, and of their finest and most volatile part. When they are deprived of their remaining part of volatile oil, their residuums exactly resemble those which remain after the rectification of essential oils. These residuums are true resins, from the analysis of which the same principles are obtained as from natural resins; and these last are nothing but balsams exhausted by time, or by the action of the air, and of the sun, of all their odoriferous and volatile parts.

There are several kinds of natural balsams. They do not essentially differ from each other, but only in the smell and degrees of consistence. The same kind of balsam also frequently differs with respect to the degrees of these two qualities.

The principal natural balsams are the *balsam of Mecca*, or the *white balsam*, which is the most rare and dear of all; the *balsams of Tolu* and of *Peru in shells*, both which Mr. Beaumé considers as the same kind of balsam, with this difference, that the first is liquid, and the second is almost dry; the *balsam of Copahu*, or of *Copaiba*, vulgarly *Capivi*; *liquid styrax*, or *storax*; and *turpentines*. *See for an example of the analysis and properties of all these balsams the word* TURPENTINE.

XCII. BALSAM *of* SULPHUR. The balsam of sulphur is a solution of sulphur in oil.

Sulphur, from the quantity of phlogiston it contains, is insoluble in water and aqueous liquors: but it is [illegible] dissolving in oils, which also contain much phlogiston.

All oils, either expressed or essential, can dissolve sulphur: to make this solution, the oil ought to be poured on the sulphur in a matrass placed in a sand-bath, and sufficient heat applied to melt the sulphur, according to Mr. Beaumé's observation, who kept these two substances a very long time together in a less heat, without perceiving any sign of solution.

While the oil is dissolving the sulphur, it acquires a reddish or brown color, an acrid and disagreeable taste, and a strong fetid smell like that of the combination of oil with vitriolic acid.

As water can dissolve only a determinate quantity of some salts, and as this quantity is greater when the water is warm than when cold, so also oils can dissolve only a determinate quantity of sulphur, and this quantity is greater when heat is applied: hence it happens, that when an oil is saturated with sulphur, by a suitable heat; a part of the sulphur thus dissolved separates from the oil, when the solution cools, and coagulates at the bottom of the vessel in a crystallized form, in the same manner as some salts do, which having been dissolved in boiling water, crystallize on the application of cold.

The

The portion of sulphur remaining dissolved in oil is in a singular state; the adhesion of its constituent parts, namely, the vitriolic acid and phlogiston, seems to be much diminished by the union they contract with the principles of the oil. Its vitriolic acid unites with the watery part of this oil; and thus these two principles have no longer the necessary relation to each other for the formation of sulphur. *See* SULPHUR.

It is certain at least, that all these changes happen when the balsam of sulphur is distilled. This is proved by the analysis which Homberg made of this combination: for by distilling it with a very slow fire, he obtained a volatile sulphureous acid, a vitriolic acid more or less strong and sulphureous, some oil, partly fluid and partly thick, and a charry residuum, but no sulphur. This is a proof that the sulphur was decomposed in the experiments as all the same products are obtained from a combination of vitriolic acid with oil, when the oil is in too great quantity relatively to the acid.

The balsams of sulphur are named from the particular oils which enter into their composition. Thus if a balsam of sulphur be made with the essential oil of turpentine, it is called *terebintinated balsam of sulphur*; if it be made with the essential oil of aniseed, it is called the *balsam of sulphur with oil of aniseed*. These are the two most used. The balsam of sulphur made with oil of nuts is called *Rulland's balsam of sulphur*. *See* SULPHUR.

XCIII. BASALTES. (*a*)

XCIV. BASIS, *or* BASE. Any body which is dissolved by another body, which it receives and fixes, and with which it forms a compound, may be called the basis of that compound. Thus, for example, the bases of neutral salts are the alkaline, earthy, and metallic matters which are saturated by the several acids, and form with them these neutral salts. In this sense it is that these neutral salts are called *salts with earthy bases*, *salts with alkaline bases*, *salts with metallic bases*; also the appellations, *basis of alum*, *basis of nitre*, *basis of Glauber's salt*, *basis of vitriol*, &c. signify the *argillaceous earth*, which, with the vitriolic acid, forms alum; the *vegetable alkali*, which with the nitrous acid, forms nitre; the *mineral alkali*, which with the vitriolic acid, forms Glauber's salt; and the *metal*, which, with the vitriolic acid, forms a vitriol: because these substances are supposed to be fixed, unactive, and only yielding to the action of the acids, which they fix, and to which they give a body and consistence.

It is proper, for the conveniency of chemical language, to retain these expressions: but these bases must not be considered as really unactive; for in every combination and solution the several bodies which unite are equally active, their action being reciprocal. They dissolve each other; so that it is as proper to say, as Mr. Gellert observes, that a metal or an earth dissolves an acid, as that an

(*a*) BASALTES is a heavy, hard stone, chiefly black or green, consisting of prismatic crystals, the number of the sides of which is uncertain. It is called by English writers *cockle*, and by Germans *Schorl*. Its specific gravity is to that of water, as 3000 or upwards to 1000. It is considered by Wallerius as a species of the *corneus* or *horn rock*. Cronstedt enumerates it among the earths which he called *Garnet earths*. Basaltes frequently contains iron, and consists either of particles of an indeterminate figure, or of a sparry, striated, or fibrous texture. Black basaltes is called *Lapis Lydius*, and is used as a touchstone, to shew the colors of metals. Basaltes has a flinty hardness, is unsoluble by acids, and is fusible by fire. *See* GARNET.

acid

acid diffolves a metal or an earth; although this latter mode of expreffion be more general. It is even probable that the diffolving power which the more weighty and fixed bodies have is really much ftronger than that of bodies lefs weighty and fixed. This is certainly fo if the tendency to unite be only an effect of the general attraction or gravitation of all particles of matter to each other. *See* COMBINATION and SOLUTION.

XCV. BATH. Chemifts call feveral matters which they employ to tranfmit heat, *Baths*. The matters moft frequently ufed for this purpofe are water and fand.

When water is employed it is called *Balneum Mariæ*, or *water-bath*. The water-bath is much ufed, and is convenient for many operations.

As water, when expofed to fire in any veffel from which it can evaporate, does only receive a determinate degree of heat, which always remains the fame, when once it has arrived to the boiling heat, it follows, that by the water-bath a degree of heat always equal may with certainty be tranfmitted. Further, this degree of heat being incapable of burning, or of communicating an empyreumatic quality to matters fufceptible of it, the water-bath has alfo the advantage of not expofing fubftances to this inconvenience. The water-bath may likewife be employed fuccefsfully for all degrees of heat inferior to that of boiling water. *See* ALEMBIC, *for the ftructure of the water-bath.*

When veffels in which diftillations and digeftions are made, are placed in fand, then a *fand-bath* is formed. This intermediate fubftance is alfo very convenient to moderate the too great activity of the naked fire, and to tranfmit any degree of heat from the weakeft to a red heat. As this bath is attended with lefs trouble, and requires lefs apparatus than the water-bath, it is much ufed in laboratories. For the fand-bath nothing is requifite but an earthen or iron veffel filled with fine fand. This veffel is fitted in to a furnace, and is capable of containing the cucurbits, retorts, matraffes, or other veffels containing the matter to be operated upon.

The only baths now generally ufed in chemiftry are thofe mentioned, the water and fand-baths, becaufe they are the moft convenient, and are fufficient for all the operations which do not require a naked fire.

Ancient chemifts, who had all a tincture, more or lefs, of alchemy, and who for that reafon were much more careful and laborious in their operations, ufed many different baths, in order to apply precifely the required degree of heat. They ufed the vapor of water, afhes, dung, the fubftance remaining after the fqueezing of grapes, and whatever they imagined moft proper for their purpofes: hence the names of *vapor-bath*, *afh-bath*, *dung-bath*, *bath of a horfe's belly*, &c. But as we have faid, an intelligent and experienced artift may very well perform all the chemical operations, which do not require a naked fire, by means of the water and fand-baths. *See* DISTILLATION *and* DIGESTION.

The word *bath* is alfo ufed in another fenfe to fignify the fufion of metallic matters in certain operations: thus, for example, in refining or cupelling, the metals are faid to be *in bath*, when they are melted. When gold is purified by antimony, this femimetal melted is called by fome chemifts the *bath of gold*. Alchemifts, who confider gold as the king of metals, call antimony, *the bath of the king only*, *balneum folius regis*; becaufe, in fact, gold only can refift the action of antimony. *See* PURIFICATION *of* GOLD *by* ANTIMONY.

XCVI.

XCVI. BDELLIUM. (o)

XCVII. BEE-GLUE. (p)

XCVIII. BEER. Beer is a spirituous liquor made from any farinaceous grain, but generally from barley. It is, properly speaking, the wine of barley. The meals of any of these grains being extracted by a sufficient quantity of water, and remaining at rest in a degree of heat requisite for the spirituous fermentation, naturally undergo this fermentation, and are changed into a vinous liquor. But as all these matters render the water mucilaginous, fermentation proceeds slowly and imperfectly in these liquors. On the other side, if the quantity of farinaceous matter be so diminished that its extract or decoction may have a convenient degree of fluidity, this liquor will be impregnated with so small a quantity of fermentable matter, that the beer or wine of the grain will be too weak, and have too little taste.

These inconveniences are remedied by preliminary operations which the grain is made to undergo.

These preparations consist in steeping it in cold water that it may soak and swell to a certain degree, and in laying it in a heap with a suitable degree of heat, by means of which, and of the imbibed moisture, a germination begins, which is to be stopped by a quick drying, as soon as the bud shews itself. To accelerate this drying, and render it more compleat, the grain is slightly roasted, by making it pass down an inclined canal sufficiently heated.

This germination, and this slight roasting, changes considerably the nature of the mucilaginous fermentable matter of the grain. The germination attenuates much, and in some measure totally destroys the viscosity of the mucilage; and it does this, when not carried too far, without depriving the grain of any of its disposition to ferment. On the contrary, it changes the grain into a saccharine substance, as may be perceived by mashing grains beginning to germinate. The slight roasting contributes also to attenuate the mucilaginous fermentable matter of the grain. When the grain is thus prepared, it is fit to be ground, and to impregnate water with much of its substance without forming a glue, or viscous mass. The grain thus prepared is called *malt*. This malt is then to be ground, and all its substance, which is fermentable and soluble in water, is to be extricated by means of hot water. This extract or infusion is sufficiently evaporated by boiling in caldrons; and some plant of an agreeable bitterness, such as hops, is at that time added, to heighten the taste of the beer, and to render it capable of being longer preserved. Lastly, this liquor is put into casks, and allowed to ferment; nature performs the rest of the work, and is only to be assisted by the other most favorable circumstances for the spirituous fermentation. See FERMENTATION (SPIRITUOUS).

XCIX. BEN. (q)

(o) BDELLIUM is a gum resin, from an ounce of which may be extracted by water six drams and two scruples, or by spirit two drams. *Neuman.*

(p) BEE-GLUE is a soft, unctuous, glutinous matter employed by bees to cement the combs to the hives, and to close up the cells. *Neuman.*

(q) BEN-NUTS yield, by expression, much oil, which, from its property of not becoming rancid, at least for years, is used as a menstruum for the extraction of the odoriferous part of flowers of jasmin, violets, roses, hyacinths, lilies of the valley, tuberoses, jonquils, clove-july flowers, and others, which, like these, yield little or no

 effential

C. BENJAMIN. *Benjamin*, or *Benzoin*, is a resin of an agreeable aromatic smell, from which an essential salt, or volatile, concrete, crystallized acid, called *flowers of Benjamin*, is obtained by sublimation. *See* FLOWERS *of* BENJAMIN. As to its other principles, it is similar to other resins. *See* RESIN.

CI. BERYL. (*r*)

CII. BEZOAR MINERAL. Bezoar mineral is the earth of the regulus of antimony deprived of all its phlogiston by the action of the nitrous acid and by calcination.

The ordinary process to make this preparation consists in dissolving butter of antimony in a sufficient quantity of nitrous acid, or till the phenomena of solution cease. If more nitrous acid be added than is necessary for the solution, no inconvenience follows, as we shall presently see.

When the solution of butter of antimony is made, it is to be evaporated to dryness in a glass or stone-ware vessel: more nitrous acid is then to be poured upon it; rather too much than too little; because an excess of this does no harm: this solution is to be evaporated, as at first; and the same operation is to be repeated a third time; after which the matter being dryed, is to be calcined for half an hour, till, according to Lemery, a very slight acidity only remains.

This operation, which was invented for the preparation of a remedy, furnishes phenomena very worthy of attention, and fit to illustrate the essential properties of the nitrous and marine acids. The following remarks then are to be made on this subject: Aqua-regia being the most active menstruum of regulus of antimony; and spirit of nitre, in which the butter of antimony is dissolved, forming an aqua-regia with the marine acid contained in this butter; a new solution is made of the reguline part, which after this is no longer united with the marine acid only, but with the nitrous and marine acids jointly, that is, with aqua-regia. When this solution is not hurried too much, it is clear and limpid; and this is the best method of having the greatest possible quantity of regulus of antimony perfectly dissolved by aqua-regia.

As upon this occasion, the nitrous acid finds the integrant parts of the regulus of antimony separated from each other by the interposition of the parts of the marine acid, and consequently the aggregation of the regulus of antimony broken, this nitrous acid seizes upon all the parts of the regulus with so much more facility and almost instantaneously: hence it happens that unless the nitrous acid be gradually added, and at long intervals, the solution is made so impetuously, that all the matter is apt to rise instantly over the containing vessel with effervescence, which happens in most solutions, and which proceeds from disengaged air. The

essential oil by distillation, but impart their fragrance to expressed oils. The method of impregnating oil of ben with the odor of flowers is this: Some fine carded cotton is dipt in the oil, and put in the bottom of a proper vessel. On this is spread a thick layer of fresh flowers, above which more cotton dipt in oil is placed; and thus alternately flowers and cotton are disposed, till the vessel (which may be made of tin, with a cover to be screwed on to it, or of porcelain) is full. By digestion during 24 hours in a water-bath, the oil will receive the odor of the flowers.

(*r*) BERYL, or AQUA-MARINA, is a polygonous pellucid gem, the tenth from a diamond in hardness, of a sea green color, and fusible by fire. This gem may be imitated by adding, at several different times, to twenty pounds of crystal-glass, made without magnesia, and well purified from glass-gall, six ounces of calcined brass or copper, and a quarter of an ounce of prepared zaffre.

quantity

quantity of air in this solution is very great. Dr. Hales has ascertained that thirty-six cubic inches of air are disengaged from the solution of half a cubic inch of butter of antimony in as much nitrous acid: but this must vary according to the manner of making the solution. Is it even certain that it is air which is thus disengaged, and not some other substance reduced to elastic vapor?

However it be, the new combination of regulus of antimony with the acids of aqua-regia is very different from the butter of antimony. The presence of the nitrous acid produces an entire change. This metallic substance is no longer united with a single acid, incapable of depriving it of its phlogiston, and which, by its intimate union, communicates to the semimetal its volatility. The nitrous acid cannot unite with the regulus of antimony without depriving it of a large portion of its inflammable principle. The regulus thus half calcined can no longer have the same adhesion to the marine acid; therefore if this new combination be exposed to the action of fire, the marine acid, which now scarcely adheres to this altered metallic matter, far from raising it, as when it was combined with no other acid, does with great facility evaporate; and the nitrous acid, which adheres still less than the marine acid to this metallic earth, quits it still more easily, and continues to deprive it more and more of its inflammable principle.

The same effects ought to take place still more upon the new additions and evaporations of the nitrous acid; therefore, after all these operations, nothing remains but an earthy white matter, absolutely fixed, unfusible, and insoluble in acids, which has no longer any emetic or purgative qualities, nor any taste, if sufficiently calcined. It is, in short, a true calx of antimony, entirely similar to diaphoretic antimony, except that to this latter preparation a small portion of the earth of the alkaline basis of nitre adheres, which is not to be found in bezoar mineral: hence we ought to conclude, that nitrous acid produces the same effects upon the regulus of antimony by the humid, as it does by the dry way.

When bezoar mineral is prepared for the purposes of medicine, it is proper not to calcine it too much; otherwise it would probably have no virtue. When it is moderately calcined, as Lemery prescribes, it may have the sudorific virtue ascribed to it, from the small quantity of acid and perhaps of phlogiston adhering to it. It is this sudorific virtue, truly or falsely ascribed, which has occasioned the name of bezoar mineral, because the animal bezoar is considered also as a sudorific.

It is evident from what has been said concerning the nature of the bezoar mineral, and what passes during its preparation, that the marine acid contained in the butter of antimony is entirely lost, and not essential to the operation, since the nitrous acid alone is capable of depriving the regulus of antimony of all its phlogiston, and of reducing it to a white calx entirely similar to bezoar mineral. Instead then of employing butter of antimony, which requires a preliminary and expensive preparation, the nitrous acid may be directly poured upon the powdered regulus, and its action assisted by heat. This acid readily corrodes the semimetal, without dissolving it; because it deprives it of its phlogiston while it attacks it, and quickly reduces it to a white calx.

When this acid is carried off, and more acid poured on, and this repeated several times, till the matter is at last calcined, a white calx of antimony is obtained entirely similar to bezoar mineral.

CIII. BILE. (s)

CIV. BISMUTH. Bismuth, called also *tin-glass*, and by some naturalists *marcasita officinarum*, is a semimetal somewhat similar to the regulus of antimony. It appears to be composed of cubes formed by the application of plates upon each other. Its color is less white than that of the regulus of antimony, and has a reddish tinge, particularly when it has been exposed to the air.

It is the heaviest of the semimetals, and loses in water about a ninth part of its weight.

It is also very fusible, and melts a long time before it is red-hot.

Bismuth is semi-volatile, like the other semimetals. When exposed to the fire, flowers rise from it; it is calcined; and converted into a litharge and glass nearly as lead is. It may even be employed, like that metal, to the purification of gold and silver by cupellation.

It easily combines with sulphur, and is thereby reduced into a striated mineral like antimony.

It amalgamates with mercury, and, according to Mr. Wallerius, it has the singular property of so attenuating tin, silver, and especially lead, when any of these metals are added to this amalgam, that a part of them passes along with the mercury through chamois leather. This sufficiently proves that this method of purifying mercury is insufficient. *(Wallerius's Mineralogy).*

Mr. Cramer, on the contrary, says that only lead, and not the other metals, can be so disposed by bismuth as to pass along with the mercury. He adds, that the lead must be previously united by fusion with the bismuth; and that if the amalgam be digested during some days, the bismuth is separated, and the lead is left attenuated with the mercury.

This semimetal is not equally soluble in the several acids.

The vitriolic acid does not, properly speaking, dissolve bismuth. If a part and a half of bismuth be mixed with one part of concentrated vitriolic acid, the whole distilled to dryness, and the residuum washed with water, the liquor drawn off is of a red yellow color, but from which nothing can be precipitated by alkalis: hence it may be suspected that the vitriolic acid attacks only the inflammable part of bismuth, and does not dissolve its metallic earth.

The nitrous acid dissolves bismuth very well.

The marine acid attacks and dissolves bismuth a little, but slowly and difficultly. Alkalis form a precipitate with marine acid in which bismuth has been digested a certain time.

This semimetal does not very sensibly detonate with nitre. It is, nevertheless, calcined by this salt, as all the imperfect metals and semimetals are.

Two parts of nitrous acid dissolve with heat and effervescence one part of bismuth. The solution is clear, limpid, and rose-colored. It coagulates into small crystals as soon as it cools.

(s) BILE *of* ANIMALS is an oily, viscid, saponaceous fluid, diffusible in water, and when thus diluted, more putrescent than other animal fluids. Inspissated bile may, by heat, be first melted, and then decomposed, yielding by distillation an urinous spirit, a volatil salt, much empyreumatic oil, and a residuum containing a considerable quantity of fixed alkali. Acids also decompose it, are thereby neutralized, and precipitate from it a resinous matter, not soluble in water, but partly soluble in spirit of wine.

This

This ſolution ought to be made gradually, to avoid too great commotion and effervescence.

Water alone being added to this ſolution, precipitates the biſmuth. The precipitate is of a very beautiful white, and is commonly called *magiſtery of biſmuth*, and by ſome artiſts *Spaniſh white*, being the ſame which is uſed as a paint for the ſkin.

To have this white very beautiful, an aqua-fortis muſt not be employed, which is adulterated by a mixture of vitriolic acid; for this latter acid gives it a greyiſh caſt.

If the nitrous acid has diſſolved but little biſmuth, much more water is ſary to effect a precipitation.

This magiſtery ought to be well waſhed, to deprive it as much as poſſibl of the adhering acid, and preſerved in a well cloſed bottle; becauſe this ſemimetal, when thus divided, has, like ſilver and lead, the property of eaſily combining with phlogiſton in vapor, and of becoming black by that addition: hence the ſkin of women painted with this white may be rendered quite black by the phlogiſtic vapors which riſe from putrefying matters, neceſſary-houſes, ſulphur, liver of ſulphur, bruiſed garlic, &c.

Alkalis alſo added to the ſolution of biſmuth occaſion a white precipitate of this ſemimetal, but not ſo beautiful as when water only is uſed; becauſe the pureſt alkalis contain ſome phlogiſton, which gives more or leſs color to the precipitate.

Some authors recommend a ſolution of ſea-ſalt in water for the making of this precipitate. But Mr. Pott, in his Diſſertation on Biſmuth, has ſhewn that the marine acid does not precipitate this ſemimetal, and ſeparate it from the nitrous acid, as it does ſilver, lead, and mercury.

Thus, although biſmuth reſembles lead in many of its properties, as the younger Mr. Geoffroy has ſhewn in the Memoirs of the Academy, ſo that ſome chemiſts have called it the lead of the ſemimetals, it appears, that, beſides want of ductility, it differs eſſentially from that metal in other reſpects.

Lemeri ſays, that if the ſolution of biſmuth be uſed to write with as an ink, that the writing does not appear, but that it becomes very black, when moiſtened with the deliquiated liquor of the ſcoria of regulus of antimony. This ſolution is therefore a ſympathetic ink. The reaſon of this phenomenon is founded on what we have obſerved concerning the property which biſmuth has, when much divided, of eaſily imbibing a ſuperabundant quantity of phlogiſton, and by that means of acquiring a black color.

The ſcoria of regulus of antimony is almoſt entirely liver of ſulphur. The alkali of this liver precipitates the biſmuth from the ſolution employed to write with; and the ſulphur or phlogiſton, diſengaged from the liver, blackens the biſmuth, which therefore becomes viſible.

It is evident after this explanation, that it is needleſs to have recourſe to the ſolution of ſcoria of regulus of antimony in this experiment; for it only acts as a liver of ſulphur, and the portion of regulus of antimony contained in this ſcoria contributes nothing to the ſucceſs: the liver of ſulphur alone may therefore be as well employed.

Biſmuth readily unites with all metallic matters, excepting, according to Mr. Gellert, zinc and arſenic; and all the allays are rendered more fuſible by biſmuth

muth. This chemist places the affinities of metallic matters with bismuth in the following order: iron, copper, tin, lead, silver, and gold. *(t)*

CV. B I S T R E. *(u)*

CVI. B I T T E R N. *(w)*

CVII. B I T U M E N. Bitumens are oily matters, of a strong smell, and of different consistences, which are found in many places within the earth.

There is only one liquid bitumen known: it is called *petroleum*, because it is an oil which actually flows from clefts in certain rocks, and it is gathered in wells dug in certain grounds and mountains. *See* PETROLEUM.

Solid bitumens are *Amber*, called also *Karubé*, or *yellow amber*; *Jet*; *Asphaltum*, or *bitumen of Judea*; and fossil or *pit-coal.*

All these bitumens, when distilled, furnish phlegm, an acid liquor frequently sulphureous, a thin oil like petroleum, a volatile acid and concrete salt, (of which amber gives the largest quantity) a black and thick oil, and lastly, a charry residuum, more or less earthy and copious, according to the nature of the particular bitumen analysed. Fossil coal furnishes the largest quantity of this residuum. From this analysis it appears, that bitumens are composed, like all other vegetable and animal concrete oily matters, of an oil and an acid. They differ in general from resins by their greater solidity; by their smell, which is stronger, and not like the aromatic smell of resins; by their insolubility in spirit of wine; by the volatile sulphureous acid; and finally, by the concrete acid obtained in their analysis.

The origin of bitumens is an interesting question, concerning which naturalists are not agreed; some imagining that they essentially belong to the mineral kingdom, and others that they proceed originally from vegetable substances. We

(t) 1. Bismuth, like iron, is said to *occupy, when fused, a less space than when solid.* 2. It is *fusible* with a heat of 460° of Fahrenheit's thermometer. 3. It greatly *encreases the fusibility of some other metals*. Thus, an allay consisting of equal parts of tin and bismuth is fusible with a heat of 280° of Fahrenheit's scale. 4. Equal parts of *gold* and *bismuth* form a brittle regulus colored like bismuth. Equal parts of *bismuth* and *silver* form a mass not so brittle as the former. A small portion of bismuth encreases the brightness, hardness, and sonorousness of *tin*. The color of *copper* is rendered less red, but not white, by bismuth. Equal parts of *bismuth* and *lead* form a dark grey compound. Bismuth may be united with *iron* by a strong heat. It does not unite with *zinc* or with *regulus of cobalt*, or only in a small proportion. 5. The *uses* of bismuth are, for making *pewter* with tin; for *soldering* some metals; for *printers types* (Homberg advises one part of bismuth and one of tin to be added to twelve parts of the common composition, which is one part of copper, one part of regulus of antimony, and five parts of lead); for *foils for mirrors*, the common mixture for this being one part of tin, one part of lead, two parts of bismuth, and ten parts of mercury; for *anatomical injections*, equal parts of lead, tin, and bismuth, to which some add a little mercury, forming a mixture sufficiently fusible; for *imitating silvering on wood*, for which purpose it is ground, applied with whites of eggs, and burnished; for *purifying gold and silver by cupellation*, for which it is preferable to lead, as it more effectually destroys imperfect metals, promotes the vitrification of earths and calxes, and combines with sulphur, forming a very fusible mass; and lastly, for *rendering some metals fitter for being cast into moulds*, as a small portion of it encreases their fusibility.

(u) BISTRE is a brown pigment, consisting of the finer parts of wo[illegible] by water from the grosser.

(w) BITTERN is the bitter saline liquor which remains after the crystallization of sea-salt in sea-water, or the water of salt springs. *See* WATER (SEA).

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must allow this latter opinion to be the most probable: for, first, no body the origin of which is certainly mineral, contains the smallest portion of oil. Even sulphur, which of all minerals approaches most to the nature of bitumens, and which all the ancient chemists have considered as such, does not contain, as Stahl has demonstrated, the smallest vestige of oil.

2dly, It is probable that the qualities by which bitumens differ from resins and other oily matters, vegetable and animal, are either the natural effects of time upon these oily matters converted into bitumens, or of an alteration produced upon them by mineral acids; or rather they are the effect of both these causes united.

Thirdly, by combining mineral acids with vegetable oils, compounds may be formed much resembling natural bitumens, and to which perhaps nothing but a sufficiently long digestion is wanting to render them true bitumens.

Fourthly, we cannot doubt that the vegetable and animal matters continually destroyed on the surface of the earth, the juices of which are capable of penetrating further, must introduce into the earth much oily matter, which, in time, may become bitumen.

Besides, natural history proves, that many entire vegetables and animals have been buried in large quantities, and even at considerable depths, by the various accidents and revolutions which have happened upon the earth; for under ground immense beds of turf are daily found, and large banks of half-decomposed, bituminous, and petrified fossil wood, which can be nothing else but considerable portions of the surface of the earth, thus buried by accidents too ancient to be remembered. All these matters are sufficient to furnish the earth with a large quantity of truly oily substance, which probably can be formed only in the organised bodies of vegetables and animals.

Junker describes, after Neuman, the Prussian amber mines, which are the richest known. First, at the surface of the earth is found a stratum of sand. Immediately under this sand is a bed of clay filled with small flints of about an inch diameter each: under this clay lies a stratum of black earth or turf, filled with fossil wood, half-decomposed and bituminous: this stratum is extended upon a bank of minerals containing little metal, excepting iron, which are consequently pyrites: lastly, under this bed the amber is found scattered about in pieces, or sometimes accumulated in heaps.

If we add to all this, that in amber are frequently included insects and fragments of plants, we shall find a further probability that bitumens are of vegetable original.

It is true that amber, petroleum, and other bitumens are found in grounds where no fossil vegetable matters exist; but it is easy to conceive that these matters may have been destroyed, and their appearance changed by time, particularly as the different natures of soils contribute much to the preservation or destruction of vegetable and animal substances.

Those bitumens which are sufficiently compact to be cut and polished, such as amber and jet, are formed into toys and ornaments, as necklaces, heads for canes, buttons, and mourning ear-rings.

Bitumens are also used for the preparation of very solid and beautiful oil varnishes. For this purpose amber is chiefly used. *See* AMBER *and* VARNISH. (*x*)

CVIII. BLACKNESS. (*y*)

(*x*) Notwithstanding the reference made in the text to *amber* and *varnish*, both these articles are omitted by the author: we shall therefore make some addition concerning *amber varnishes*.

A *fine black varnish* may easily be made by dissolving amber previously melted in a crucible till it is rendered black, in boiling linseed oil. But the solution of amber without decomposition, by which its color is altered, in linseed or other expressed oils, is more difficult, and has been unsuccessfully attempted by Neuman and other chemists. Hoffman says, that he reduced amber and oil of olives to a gelatinous mass by placing the glass-vessel containing them in Papin's Digestor, one third part of which was full of water. The experiments of Dr. Stockars are more decisive. He says, that, by continuing a simmering heat during twelve hours, and by confining the vapors as much as stone-ware vessels would bear, powdered amber was perfectly dissolved in expressed oils, in turpentine, and in balsam of copaiba. He prevented the vessels from bursting, by making small notches in the corks with which he stopped them. The solutions of amber in oils of rape-seed and of almonds had a fine yellow color; in oil of linseed a golden color; in oil of poppy a yellowish red; in oil of olives a beautiful red; in oil of nuts a deeper red; in oil of bays a purplish red. Solutions of amber in turpentine and balsam of copaiba had a deep red color, and when cooled, formed hard brittle red masses. All these solutions were easily miscible with spirit of turpentine. Those made with oils of linseed, bays, poppies, and nuts, with balsam of copaiba, and with turpentine, being diluted with four times their quantity of spirit of turpentine, formed hard, tenacious, glossy varnishes, which dried sufficiently quick. See *Dr. Stockars's Specimen Inaugurale de Succino, Leyden*, 1760.

Amber may be rendered clear and pellucid by two methods. 1. By cementing lumps of it with sand, during 40 hours, in an iron pot. 2. By digesting them during 20 hours in boiling rape-seed oil.

A *tincture* may be extracted from amber by rectified spirit of wine, or by sweet spirit of vitriol.

From 16 oz. of coarse amber Neuman obtained, *by distillation*, eleven ounces six drams of oil, four drams and a half of salt, (*see* SALT *of* AMBER) one ounce and a half of water, and nearly one ounce of caput mortuum.

(*y*) BLACKNESS. Dr. Lewis, in his *Philosophical Commerce of Arts*, has written copiously concerning the substances capable of communicating blackness. What we shall say on this subject shall be chiefly extracted from that work.

"The *native black coloring materials* are, 1. *Black chalk*, or *black marking stone*, which seems to be a slaty bituminous substance, unsoluble by acids, and capable of being rendered friable and red by fire. It stains freely. When powdered, it does not lose its blackness, and may then be formed with oil into a paste, or with water into a slimy mass; which properties render it useful to painters. 2. *Pitcoal* mixed with oil produces a brownish black. 3. *Black sand* found in Virginia, strewed upon writing while yet wet, dries and gives lustre to the ink. This substance might be used in oil painting to give a sparkling black. What this substance is Dr. Lewis has not mentioned. I have essayed a black sparkling powder usually sold for strewing upon writing, and found it to consist of minute particles of the lead-ore called *galena*. 4. *Black-lead*, the color of which is rather a deep shining blue than a black, is smooth and unctuous, and hence is used, as soap and oil are, to prevent the friction of machines. It is unsoluble by acids, and unfusible by fire: in close vessels it is unalterable by fire; but by a long calcination in an open fire it is mostly volatilised, emitting, according to Lawson, (*Dissertatio de Nihilo*) inflammable blue flowers, and the residuum is a yellow calx, which being reduced by Mr. Quest, (*see Swedish Acts*, 1754) seemed to be a mixture of iron and tin. Black lead may be readily mixed with melted sulphur, and of this composition pencils are formed much inferior

CIX. BLACK-JACK. (z).

CX. BLOOD. Blood is well known to be a red liquor in most animals.

ferior to those made of slips of entire black lead fitted into pieces of cedar wood. 5. *Black vegetable juices.* The excellent black varnish of China and Japan is a native juice exuding from incisions made in certain trees, one of which is said to be that, the fruit of which is brought to Europe, called *anacardium.* Anacardium contains a black juice which gives to linnen and cotton a reddish brown stain, which, by exposure to air, becomes black, and is incapable of being discharged by [illegible] boiling with soap or alkaline [illegible] oriental varnish is said by others [illegible] produced from the tree called [illegible]. 6. *Cuttle-fish* contains in a [illegible], a fluid as black as ink, and which is said to be fit for the [illegible] purposes.

[illegible] *coloring materials produced by fire* are. 1. [illegible], which, entire or powdered, is [illegible] this purpose artists use the [illegible] of trees, chiefly of the soft woods, as willows and vines, [illegible] from the bark and pith. The coal of [illegible] and other animal substances is glossier and deeper colored than vegetable coals: [illegible] is superior to the rest. 2. *Soots* are softer than coals, and more easily miscible with oil or water. A part of wood soot is soluble in water. From an infusion in wood soot in water is prepared the brown pigment called *Bistre*, used for painting in water-colors. The finest of the soot blacks is *lamp-black*, [illegible] prepared by burning in an oven the dregs and [illegible] of pine-bark left in the process [illegible] common rosin. Soots prepared by [illegible] pieces of wood or of mineral bitumen very slowly under a copper pan, were found by Dr. Lewis to be not different from those prepared from oils and resins; and, like these, contained nothing soluble in common water, as the soot collected in common chimneys does. *See* SOOT.

The *black-coloring materials produced by mixture* are, 1. A solution of green vitriol in water, added to an infusion of galls or some vegetable astringent, is the basis of black inks, and black dyes for the uses of callico printers, tanners of leather, hatters, dyers, &c. The color given by this mixture adheres permanently to silk and wool, but may be discharged from linnen and cotton by washing. If the water employed for dissolving the vitriol, or infusing the galls, have been distilled, or [illegible] common spring water, or fresh [illegible] produced will be bluish; and if the water [illegible] any putrid or alkaline quality, the color produced will have a [illegible]. The blackness given by galls [illegible] improved by addition of [illegible] table astringents do not produce [illegible] by mixture with solution of green vitriol. Thus the Peruvian bark is said to give a greenish color. *See* INK. 2. A *solution of silver* in nitrous acid gives black stains to solid white animal substances, to agates, and some other stones, afterwards exposed to the sun and air. Bones and hair at [illegible] receive no stain, but sooner or later, as they happen to be more or less exposed to the sun and air, they become of a reddish or purplish color, which gradually changes to a brown, and afterwards to a black. Mr. Schulze (*Act. Natur. Curios. vol* I.) says, that white chalk moistened with solution of silver, by exposure to the sun, acquires a purplish black color on its surface, which [illegible] be interrupted by threads shading parts of the chalk. If the chalk, thus moistened with solution of silver, be dried in the shade or by fire, no color will be produced. No color was given by this method to white clay, talk, or plaster of Paris. The action of solar light also gives a dark color to the white precipitate of bismuth, and to [illegible] mercury. 3. A black stain is given to [illegible] or other white substances, by [illegible] *in acids*, when these substances are afterwards exposed to phlogistic or sulphureous vapors. *See* INK (SYMPATHETIC). [illegible] *melted with sulphur* form a black or blackish mass useful for taking casts from medals, as it is less brittle than sulphur alone. Mr. Le Blon found that a black color may be produced by mixing blue, red, and yellow pigments; and Mr. Castel directs that fifteen parts of blue should be mixed with five parts of red, and three of yellow, and that each of these colors should be very deep. Dr. Lewis tried such mixtures, but produced only a brownish or greyish black.

(z) BLACK-JACK, or BLEND, is a mineral, called also *false galena.* See GALENA (FALSE).

circulating in their veſſels during life, and the common ſource whence all the neceſſary and ſuperfluous animal liquids are derived. (*a*)

Blood newly drawn from a ſound animal gives no ſign of an acid or alkaline quality. It has a ſweetiſh and ſomewhat ſaline taſte. When left to itſelf, it coagulates, and quickly paſſes to a fermentation at firſt a little acid, and afterwards entirely putrid, in the ſame manner as all other perfectly animaliſed ſubſtances.

This liquor contains nothing volatile by the heat of boiling water, but a pure phlegm. Thus when blood is diſtilled in a water-bath, it is only dried, not entirely decompoſed. By this drying it loſes $\frac{7}{8}$ of its weight. The reſiduum being diſtilled in a naked fire, yields volatile alkali, and animal oil, at firſt thin, and afterwards thick: in the retort a charry reſiduum remains, which can difficultly be reduced to aſhes, from the lixiviation of which a little common ſalt may be obtained.

From this analyſis, which is almoſt all that chemiſts have done to diſcover the nature of the blood, it appears that this liquor contains the ſame principles as all other perfectly animaliſed matters. But a more accurate examination might probably be made of it by ſeparating at firſt from each other ſeveral different ſubſtances, of which the blood is only a collection or mixture, and then by analyſing each of theſe ſubſtances, as has been done with milk.

In fact, the blood being opake, or not very tranſparent, appears to be, as milk is, nothing elſe than a mixture of ſeveral heterogeneous matters confounded together, without being diſſolved by each other. It is known, that, when the blood is no longer circulated in the veſſels of the animal, but left at reſt in a veſſel, it coagulates and ſeparates ſpontaneouſly into a red maſs, and a white liquor, or ſerum, in which the red maſs floats; and that by waſhing, the red part of this maſs may be carried off, and the remaining matter is white and gelatinous. There are then three diſtinct matters in the blood which ſeem to correſpond with thoſe contained in milk; that is, the ſerum of the blood correſponds with the whey of milk; the white gelatinous matter, with the cheeſy part; and laſtly, the red globules with the butyraceous ſubſtance.

It is ſo much more probable that the red part of the blood is oleaginous, as anatomiſts, who have examined the blood by microſcopes, have obſerved that this red part is compoſed of globules ſwimming in a white liquor, and as all oily matters, when well mixed, but not diſſolved in a watery fluid, have this globular appearance. (*b*)

This being eſtabliſhed, if the blood were to be examined more exactly than it has hitherto been, it would probably be neceſſary to begin by ſeparating from each other the three above-mentioned ſubſtances, each of which ought afterwards to be ſubjected to experiments and analyſes, as has been done with milk. It is probable that this method of analyſing blood would throw new light upon its

(*a*) The color of blood, like that of many other ſubſtances, is affected by expoſure to air, by which it acquires a ſcarlet tinge. Arterial blood has this ſcarlet color, which it has acquired by paſſing through the lungs in reſpiration. The blood flowing through the veins has a deeper and leſs vivid red color. It acquires the ſcarlet color by expoſure to air, and arterial blood loſes its vivid red color by excluſion from air.

(*b*) The red particles of blood are ſaid to have an annular form.

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nature and principles, which are yet very imperfectly understood, as well as those of other animal matters.

The purely gelatinous parts of the blood are probably not different from any other animal jelly; but it is to be presumed that some peculiar salts might be obtained from the serous parts, as have been from milk and from urine; and that the red globular part would be found to be oleaginous. The acid, or volatile alkaline principles which would be obtained from the red part of the blood would determine whether or not it is a truly animal oil, or fat. If it be true, as Mr. Homberg and Mr. Macquer affirm, that some acid may be obtained by analysing the blood, it would probably be found to belong to this red substance.

Lastly, it is evident that whatever knowledge could be acquired on this subject by well-conducted experiments, must extend and encrease an interesting branch of our knowledge, namely, that concerning animal economy. (c)

CXI. B L U E. (d)

(c) Dr. Fordyce, in his very excellent Elements of the Practice of Physic, says, that the white gelatinous matter of the blood, or *coagulable lymph*, continues fluid while circulating with any degree of heat betwixt 30 and 120° of Fahrenheit's thermometer; but that it is coagulated very soon after it is taken out of the body in any heat, in motion, or in rest; and that its coagulation may be prevented by saturating the blood with sea-salt, or perhaps with some other neutral salts. The coagulum is rendered soluble in boiling water, by putrefaction, by concentrated acids, caustic alkalis, calcareous earths, and by some metallic salts. He observes also, that the coagulable lymph is more fluid, and is not so easily coagulable when the arteries of the person from whom the blood is drawn act more strongly than they usually do; in which case, the red particles and this lymph can separate more exactly from each other according to their densities, the former falling to the bottom, and the greatest part of the latter forming upon the upper surface a very viscid tough mass called the *buff*. By putrefaction the coagulable lymph and serum are converted into a mucilaginous matter, not coagulable by any of the methods recited above, which mucilaginous matter may be converted by further putrefaction into saline substances and calcareous earth. The red part of the blood is readily soluble in water, but not in serum, nor in a saturated solution of neutral salts. By the first stage of putrefaction this red part of blood is broken down into smaller particles, its color is rendered darker, and afterwards it is converted to a mucilage soluble in serum.

(d) BLUE COLORING MATERIALS. No blue materials for dying consist of animal or mineral substances. Concerning the blue glass called *smalt*, prepared from the ore or regulus of cobalt; the preparation of iron called *Prussian blue*; and the preparation of lapis lazuli called *ultramarine or azure*, see SMALT, AZURE, *and* BLUE (PRUSSIAN). The *blue color of flowers* is so perishable as to be of little use in dying. It is extracted from many by infusion in water, but not in spirit. It is changed by acids to a red not more durable than the original blue; by marine acid to the most florid red; and it is changed by alkalis and by lime-water to a green, which afterwards becomes a yellow. The green by lime-water is the more permanent and beautiful, and has been formed into lakes for painting. The two principal vegetable substances used for dying of a blue color are *indigo* and *woad*. These are feculæ or sediments deposited by fermentation from infusions of the leaves of the plants *anil*, and *woad*, or *glastum*. Hellot thinks, that a similar blue dye might be obtained from most other vegetables, and that the green of vegetables is caused by a mixture of blue and yellow coloring particles, of which the blue is the most durable, and least affected by fermentations. The colors given by both indigo and woad are at first green, but are soon changed, by exposure to air, to blue. A blue tincture may be made from *nephritic* wood, which has not been applied to any use. The *essential oils of camomile, milfoil, pimpinella nigra*, are blue, and by keeping become green and yellow. *See* DYING.

CXII. BLUE (PRUSSIAN). Prussian blue is a precipitate of iron with a superabundant quantity of phlogiston, from which it receives a very beautiful color.

This blue, which is successfully used in painting, was discovered, like most other things, by accident, and about the beginning of this century.

A chemist of Berlin having successively thrown upon the ground several liquors from his laboratory, was much surprised to see it suddenly stained with a most beautiful color. He then recollected what liquors he had thus thrown upon each other, and having made a similar mixture in a vessel, he saw the same blue color appear. As he perceived that this discovery might be profitable to him, he did not publish the process, but prepared this blue for the use of painters, who found that it might be substituted for ultramarine, a very dear color, and from that time made much use of it.

An account of this blue, called *Prussian* or *Berlin blue*, from the place where it was made, was published in the Berlin Memoirs for 1710, but no description was given of the process for making it.

Several chemists undoubtedly attempted to discover it: accordingly it was discovered, and in the year 1724 Dr. Woodward published it in the Philosophical Transactions. The process succeeds very well, and is as follows:

Alkalise together four ounces of nitre and as much tartar. *See* ALKALI (EXTEMPORANEOUS). Mix this alkali well with four ounces of dried bullock's blood, and put the whole in a crucible covered with a lid in which there is a small hole: calcine with a moderate fire till the blood be reduced to a perfect coal; that is, till it emits no more smoke or flame capable of blackening any white bodies that are exposed to it: increase the fire towards the end, so that the whole matter contained in the crucible shall be moderately, but sensibly red.

Throw into two pints of water the matter contained in the crucible, while yet red, and give it half an hour's boiling: decant this first water, and pour more water upon the black and charry coal till it becomes almost insipid: mix together all these waters, and reduce them by boiling to about two pints.

Also dissolve two ounces of martial vitriol, and eight ounces of alum in two pints of boiling water: mix this solution when hot, with the preceding lixivium, also hot. A great effervescence will then be made. The liquors will be rendered turbid, and will become of a green color more or less blue, and a precipitate will be formed of the same color. Filtrate, in order to separate this precipitate, upon which pour spirit of salt, and mix them well together, by which means the precipitate will become of a fine blue color. It is necessary to add rather too much spirit of salt than too little, and till it no longer encreases the beauty of the precipitate. The next day wash this blue till the water comes off from it insipid, and then gently dry it. Such is the process by which Prussian blue is made. Chemists, after having discovered it, endeavored to find the theory of it, and to explain the appearances in the several operations of the process. There have been several opinions concerning the nature of Prussian blue.

Mr. John Brown of the Royal Society of London thinks, that this blue is the bituminous or phlogistic part of iron, disengaged by the lixivium of bullock's blood, and applied to the earth of alum. This opinion has been adopted by Dr. Geoffroy in the Memoirs given by him on this subject, which are found in the collection of the Academy of Sciences for the year 1725.

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The Abbé Menon, a correspondent of the Academy of Sciences, in Memoirs printed amongst the collection of the *Scavans Etrangers*, published by the Academy, advances and endeavors to prove that Prussian blue is nothing but iron entirely freed from all saline matter by the phlogiston of the alkaline lixivium, and precipitated with its natural color, which, he pretends, is blue. He thinks that the use of the alum is to diminish the intensity of the color by the whiteness of its earth.

Lastly, Mr. Macquer, having examined this matter in all its extent, has published a memoir amongst those of the Academy of Sciences for the year 17[illegible], in which he concludes, after having related many experiments, that Prussian blue is nothing but iron impregnated with a superabundant quantity of phlogiston, which it receives from the phlogisticated alkaline precipitant. The experiments and discoveries made by this chemist are as follow.

Mr. Macquer first observes that very pure alkaline salts separate iron, as they do all metallic substances, from acids; and that iron so precipitated has a color more or less yellow, and is soluble by acids.

If, on the contrary, this precipitation of iron be made by an alkali previously calcined with an inflammable matter, then a precipitate is formed, more or less green or blue, as the alkali was more or less phlogisticated.

If an acid be poured upon this green precipitate, experiments shew that the acid dissolves one part of it, and does not act upon the other. This proves that the green precipitate is not homogeneous, but a mixture of two precipitates, one of which is soluble, and the other is insoluble by an acid.

As the precipitate which resists the action of acids is very blue, when separated from that which the acid has dissolved, and as the green color of the mixed precipitate is a mixture of yellow and blue; the author concludes that the part dissolved by the acid is yellow, and consequently that this portion of green precipitate is entirely similar to the iron which pure alkalis separate from acids.

As to the blue precipitate, as it not only resists the action of acids but also of magnets, it might not be known to be iron, if a slight calcination did not at once deprive it of its blue color, and render it entirely similar to other iron.

These facts prove that Prussian blue is nothing but iron united with some matter which gives it a blue color, and the property of resisting the action of acids and of magnets.

Mr. Macquer has further discovered that fire is not the only means by which the Prussian blue may be deprived of all the properties, by which it differs from ordinary iron.

A very pure alkali produces also the same effect. He has also discovered, that the alkali which has thus deprived the Prussian blue of all the properties which distinguish it from ordinary iron, becomes by that operation entirely similar to the phlogisticated alkali used for the preparation of Prussian blue.

These facts seem to demonstrate that Prussian blue is nothing else than iron, which becomes blue by impregnating it with with a matter which the alkali is capable of giving to it or of separating from it, according to circumstances; that is to say, that when the alkali is impregnated with this matter, and is applied to iron dissolved in an acid, it then combines with this acid, and precipitates the iron, to which it transfers at the same time the matter which changes the iron into Prussian blue. But if on the contrary Prussian blue be applied to pure

alkali, then this alkali entirely dissolves the coloring matter of the Prussian blue, and takes it from the iron, which is thus reduced to its ordinary condition.

By a more particular examination of this alkali, impregnated with the coloring matter of Prussian blue, either by calcination with an inflammable matter, or by taking the color from Prussian blue itself, Mr. Macquer found that its alkaline properties were so much more weakened, as it was impregnated with a larger portion of this coloring matter. This induced him to presume, that by giving it a sufficient quantity of Prussian blue to discolor, it might be entirely saturated with this coloring matter: and the event entirely answered his expectation.

By applying much Prussian blue to an alkali, this latter was so saturated that it no longer discolored the blue when boiled together, and upon trial, was found to possess no longer any alkaline qualities.

A solution of iron by any acid poured into this alkali, saturated with the coloring matter of the Prussian blue, forms immediately a precipitate, not green, composed of yellow and blue, the former of which must be separated by an acid from the latter to obtain this of a pure blue color, as in the or
cess for the preparation of Prussian blue, but a single homogeneous
and a perfect Prussian blue. This effect ought necessarily to happ
the saturated alkali contains no part purely alkaline which can occasion a precipitate of soluble iron, as pure alkalis do.

But an essential phenomenon, and not observed by any former chemist, is, that it is not merely by the action of the acid, which dissolves the iron, that the coloring matter is applied to the iron, and thus the Prussian blue formed; but that the affinity of this matter to iron contributes also to produce this effect. The author has demonstrated this truth by the following decisive experiment.

If any pure acid be poured upon an alkali perfectly saturated with the coloring matter of Prussian blue, this acid contracts no union with this alkali, nor is any-ways neutralized, and consequently is incapable of separating the coloring matter of Prussian blue. It only procures this separation when it is united with iron, the affinity of which to the coloring matter, being joined to the affinity of the acid to the alkali, form a sum of affinities capable of occasioning the separation of which we treat.

In this operation, therefore, there is a very distinct example of the effect of double or united affinities. *See* AFFINITY. This example is even so much more compleat, as it is amongst the most general that chemistry furnishes. For according to Mr. Macquer's observations, iron is not the only metallic substance, the affinity of which being united with that of the acid, procures the separation of the coloring matter of the Prussian blue from the alkali; but any metallic substance dissolved in any acid separates the phlogistic matter from all alkalis, fixed or volatile. This is ascertained by Mr. Macquer's experiments, a detail of which may be seen in his memoir.

Another no less important phenomenon, which none of the chemists who have endeavored to explain the theory of Prussian blue had observed, is, that earths have not the same affinity as metallic substances with the phlogistic matter of Prussian blue. Hence if an alkali saturated with this coloring matter be poured into a solution of alum, no decomposition is effected, nor is any precipitate formed.

formed. The alum continues alum, and the ſaturated alkali remains unchanged.

After this experiment Mr. Macquer reaſonably concludes, that the alum added in the operation of Pruſſian blue does not directly contribute to the production of this blue. The purpoſe to which it ſerves is as follows.

This chemiſt proved by many experiments, that alkali ſalt can never be entirely ſaturated with the coloring matter of Pruſſian blue by calcination. This being eſtabliſhed, it is certain that alkalis, calcined with inflammable ſubſtances to make the proper lixivium for Pruſſian blue, ſtill remain alkaline. Hence it happens that when they are mixed with a ſolution of green vitriol, they form by their purely alkaline part a yellow precipitate, ſo much more copious as this purely alkaline part is itſelf more copious. But nothing is more capable of ſpoiling the color of the portion of iron precipitated in Pruſſian blue than a mixture of this yellow or olive-colored precipitate; therefore a large quantity of acid muſt be employed, that this yellow precipitate may be entirely diſſolved, if we mean to have a very fine blue.

Part of theſe inconveniencies is avoided by mixing a ſolution of alum with a ſolution of green vitriol. By this means, the purely alkaline part of the lixivium is moſtly employed to precipitate a greater or leſs quantity of the earth of alum, and conſequently the quantity of yellow ferrugineous precipitate is much diminiſhed. But the earth of alum being of a fine ſhining white does not in the leaſt alter the purity of the blue color, but enlivens it, and leſſens its intenſity; which is frequently no inconvenience, becauſe the Pruſſian blue, when it is not of the fineſt color, is always too dark and black.

It follows from what has been ſaid, that when Pruſſian blue is to be made with a lixivium not ſaturated, it is a matter of indifference whether the green precipitate is to be again diſſolved, or the alkaline part of the lixivium ſaturated with alum or with an acid, before the precipitate is formed. The only difference which can proceed from theſe modes of management is, that in the former caſe all the part of the precipitate which is not Pruſſian blue is rediſſolved by an acid; whereas in the latter caſe, this mixed precipitation is prevented, and nothing is thrown down but true Pruſſian blue.

It is proper to obſerve, concerning the theory of Pruſſian blue, that moſt alkalis obtained from the aſhes of vegetables, being combined by their combuſtion with a portion of inflammable matter, are capable of furniſhing a quantity of Pruſſian blue proportionable to the quantity retained by them of this inflammable matter, even without the neceſſity of mixing them with a ſolution of iron, becauſe they always contain a little of this metal diſſolved, ſome of which may be found in almoſt all vegetables; therefore it is ſufficient for this purpoſe to ſaturate them with an acid. Theſe materials which form Pruſſian blue in alkaline ſalts occaſion their impurity, and require much trouble to be perfectly ſeparated.

Some chemiſts had even perceived the production of this blue in the ſaturation of alkaline ſalts, before the diſcovery of the Pruſſian blue: and Henkel particularly, who had obſerved it in the ſaturation of ſal ſoda, or foſſil alkali, recommended to chemiſts an enquiry concerning the nature of this blue. Thus chemiſts had already acquired ſome ſort of knowledge on this ſubject, and therefore the Pruſſian blue could not have long remained unknown, even if acci-

dent

that had not presented it in so striking a manner to the chemist of Berlin, who was the first who prepared it in sufficient quantity for the uses of painters.

CXIII. BOLE. Boles, or bolar earths, are clays which adhere to the tongue, when applied dry, and which are colored, yellow and red, by a ferrugineous earth. *See* Clay.

CXIV. BOLOGNIAN STONE. *See* Stone.

CXV. BONES. (*c*)

CXVI. BORAX. Borax is a saline matter, with all the properties of a ...

It is soluble in water, and crystallizable nearly as alum is; with this difference only, that it requires a little more water for its solution, and retains somewhat less in its crystallization.

When exposed to fire, it at first undergoes the liquefaction occasioned by the water of its crystallization, and is then calcined, as alum is, but is not so much swelled and rarefied during the operation.

If the fire be increased to a melting heat, the borax is pretty easily fused, and is converted into a vitreous matter, or saline glass: and when it is mixed with earths of any kind, it acts as a flux, and converts them into more or less transparent glasses according to their natures. *See* Vitrification.

Glass of borax is very friable, easily tarnishes in the air, and becomes mealy, nearly as the alkaline basis of sea-salt does. It is entirely soluble in water; and when the solution of it is evaporated, borax is again formed in crystals, as it was before its fusion.

Borax then suffers no decomposition by fire, even in open vessels, and certainly, therefore, not in close ones.

But it may be decomposed by the vitriolic, nitrous, and marine acids, which unite with the saline alkaline matter which is its basis, and form with it exactly the same neutral salts as those which result from the union of these acids with the marine alkali; that is to say, the vitriolic acid forms Glauber's salt; the nitrous acid forms cubic nitre; and the marine acid forms sea-salt.

When acids combine thus with the alkaline basis of borax, they separate from it a saline substance of a singular nature, and little understood, called *Sedative salt*. *See* Salt (Sedative.)

We are far from knowing as much concerning borax as is desirable. We are even ignorant of its origin, which might supply the want of a perfect analysis, and give light to the nature of this saline substance.

As borax is not found in Europe, it is brought from the East-Indies in a state which only requires a slight purification, which is given to it by the Dutch and Venetians

(*c*) Bones are totally soluble in concentrated acids of vitriol, nitre, and sea-salt, and may be softened by these or acetous acids diluted. From two ounces of ox-bone Neumann obtained by distillation two drams of empyreumatic phlegm, one dram of volatile urinous spirit, two scruples of volatile alkali, two scruples of fetid oil, and one ounce, three drams, and two scruples of residuum. Dr. Lewis observes, that bones exposed to a heat gradually raised are rendered white, opake, and friable; and when exposed suddenly to a violent heat, are rendered hard, semi-transparent, and sonorous. Bones and horns may be stained by the common dying infusions and decoctions of vegetable and animal substances, and by metallic solutions.

Venetians who are the chief merchants of it. But it is not yet known whether this matter be a natural or an artificial ſubſtance, nor whence, nor how it is obtained.

Our ignorance concerning borax is certainly owing to the intereſt, which they, who make a lucrative commerce of it, have to keep every thing concerning its origin ſecret.

However that be, notwithſtanding the reſources which chemiſts poſſeſs of diſcovering what is hid from them by their experiments, it appears that they were long in a ſtate of indifference concerning borax. Satisfied with employing it in their operations, in which it is very uſeful as a flux, they long uſed it without attempting to ſubject it to proper proofs for the diſcovery of its nature.

In the writings of Becher and Stahl we ſcarcely find any thing concerning borax. The examination by chemical means of this ſubſtance, which ought to excite the curioſity of chemiſts, has been begun only in theſe latter times; and it is to the praiſe of the French, that almoſt all the knowledge we have concerning it we owe to them alone.

Homberg was amongſt the firſt who undertook a ſet of experiments on borax, by which the ſedative ſalt was diſcovered, which was a new ſubſtance, and entirely unknown before him. Homberg obtained the ſedative ſalt from borax, by diſtilling it with vitriol; and imagining that he diſcovered a ſedative or quieting power in it, he called it the *Narcotic Salt of Vitriol*, or *Sedative Salt*. This chemiſt did not well underſtand the theory of his experiment; but that is not ſurpriſing in matters ſo new.

The younger Lemeri, who after Homberg made many experiments on borax, diſcovered that ſedative ſalt may be obtained from it not only by the vitriolic acid, but alſo by the nitrous and marine acids. This diſcovery was the more important, as it naturally led to further: but he ſeems to have been prevented by other purſuits from continuing this ſubject as it ought to be.

Homberg and Lemeri obtained ſedative ſalt only by diſtillation or ſublimation, which, particularly in this caſe, was a long and embarraſſing operation. M. Geoffroy has improved upon their diſcoveries, by ſhewing the method of obtaining the ſame ſalt from borax by acids with evaporation and cryſtallization only, in greater quantity and with leſs trouble We are alſo obliged to him for having firſt demonſtrated that borax contains the baſis of ſea-ſalt. This truth he has firmly eſtabliſhed, by obtaining a true Glauber's ſalt by mixing vitriolic acid with a ſolution of borax.

Laſtly, Mr. Baron, Member of the Academy of Sciences, and of the Faculty of Medicine at Paris, proved by many experiments that ſedative ſalt of borax may be obtained by means of vegetable acids, which had not been done before him. He has alſo proved, that ſedative ſalt is not a combination of an alkaline matter with the acid employed to obtain it, but that it exiſts ready formed in borax, of which it is a principle or conſtituent part; that the acids employed to extract it do only diſengage it from the alkali with which it is united; that this alkali is entirely ſimilar to that of ſea-ſalt; that ſedative ſalt may be re-united with its alkali, and again form borax; which is a compleat proof that borax is nothing elſe than a compound of ſedative ſalt, and marine alkali.

S Nothing

Nothing more then remains to have, on the nature of borax, all the knowledge we can desire, than to discover what this sedative salt is. The experiment by which Mr. Baron found that this salt is capable of decomposing nitre and marine salt, by separating the acids of these salts by help of fire, seems to shew that vitriolic acid is one of the principles of the sedative salt. But to prove this decisively, the sedative salt itself must be decomposed. This is the subject of Mr. Bourdelin's late admirable experiments. Although this able chemist has not been able to accomplish his purpose by all the methods which the most profound chemistry can suggest, his experiments are nevertheless useful, as they m y prevent others from employing their time and labor in making them, and also because they make us better acquainted with the properties of the sedative salt. *See* SALT (SEDATIVE). *(f)*

CXVII. BRAINS. *(g)*

CXVIII. BRANDY. *(h)*

(f) *Borax*, when crude, as it is brought from the East-Indies, is called *Tincal*. In this state, it consists of small, yellow, glutinous crystals. It is said to be refined by lime water. Refined borax consists of large, white, eight-sided crystals, each of which is composed of small, soft, bitterish scales. It is difficultly soluble in water, to which it gives a glutinous quality, and hence is used by dyers to give a gloss to silks. It is also soluble in spirit of wine, to the flame of which it gives a green color. By repeatedly moistening it, while it is considerably heated, it may be entirely sublimed. Borax renders all earths and stones fusible by fire, and hence is used for the essaying of ores. It also facilitates the fusion of metals; and is particularly useful when small particles of metal mixed with dirt and ashes are to be melted together; as it promotes the fusion of the metal, and the vitrification of the other matters, by which the particles of metal may disengage themselves, and collect into one mass. It is further useful in the fusion of metals, as it defends their surfaces from the combined action of air and fire, by which imperfect metals are calcined. Crucibles in which gold and silver are melted ought to be previously glazed on their inner surfaces with borax, that when the metals are poured out, no particles may adhere to the sides of the crucibles. Gold is rendered pale by fusion with borax, which effect is prevented by adding a little nitre or sal-ammoniac, or is remedied by remelting the gold with either of these salts. Dr. Lewis observes, that borax also renders brass and Prince's-metal pale, and at the same time acquires a deep red color. This color it probably receives from some part of the copper contained in these compound metals, as it acquires the same red color by fusion with copper. Borax is not, as some suppose, a substance capable of reducing or reviving calcined metals, but is

principal use of borax is to facilitate the soldering of metals, which it does by accelerating the fusion of the surfaces of the metals to be joined, and by clearing them from any calx or other matter by which they might be prevented from being perfectly applied to each other. Borax is also used for the preparation of some fine glasses, and imitations of precious stones; because the glasses prepared by fusing it with earths are very hard, compact, bright, and very transparent; but by long exposure to air they lose much of their lustre, become cloudy, and when the quantity employed has been large, even opake.

(g) BRAINS. From 16 oz. of ox's brains, Neuman obtained by distillation six ounces, two drams, and two scruples of a colorless phlegm; four ounces and four scruples of a volatile, empyreumatic spirit; which being rectified, produced two scruples of a volatile, concrete salt, and one ounce of caput mortuum, from which, by elixation, were procured 25 grains of fixed salt.

(h) BRANDY is an ardent spirit distilled from wine. For its properties, *see* SPIRIT. It may be imitated by adding to very pure malt spirits some dulcified spirit of nitre.

CXIX. BRASS (*i*). Brass, called also *Latten*, is a mixture of very pure copper, with a fourth part of very pure zinc, by which the color of the copper is rendered of a fine golden yellow. This is undoubtedly the most useful and necessary of all the mixtures of copper and other metals, chiefly on account of the copper's preserving so much of its ductility, when combined with that proportion of zinc.

(*i*) Brass. As the manufacture of brass is important in commerce, a detail of the process by which it is made may be acceptable. The calamine is previously to be prepared by cleansing it from adhering earth, stone, or other matters; by roasting or calcining it; and by grinding it into a fine powder. The calcination, by which moisture and small portions of sulphur and other volatile matters are dissipated, may be performed either in a reverberatory furnace, in which the calamine is kept till it be thoroughly red hot; and that this heat may be more equally given to it all at the same time, it ought to be frequently stirred; or by setting fire to a conical pile, composed of horizontal layers of calamine, and of charcoal placed alternately one upon the other, and of a lower stratum consisting of large pieces of wood; in which lower stratum are four horizontal channels, through which the air maintaining the fire passes to the center, and thence arises through a chimney or perpendicular empty space, left for that purpose, along the axis of the conical pile. If the calcining heat be too intense or too long continued, part of the contained zinc may be dissipated; and if it be not sufficiently intense, or long enough continued, the volatile matters will not be entirely expelled, and the texture of the stone will not be sufficiently broken to prepare it for the subsequent grinding. The length of time and degree of heat requisite for the calcination of calamine, are different according to the qualities of that mineral. The calamine thus cleansed, calcined, and ground, is to be mixed with about a third or fourth part of powder of charcoal, or of pit-coal, as is done in some parts of England. The malleability of the brass is diminished by the use of pit-coal, which is therefore employed only for the preparation of coarser kinds of brass. To this composition of calamine and coal some manufacturers add common salt, by which the process of making brass is said to be hastened. In Goslar, where the cadmia adhering to the inner sides of furnaces is employed, instead of native calamine, a small quantity of alum is added, by which they pretend the color of the brass is heightened. With this composition, and with thin plates or grains of copper, the crucibles are to be nearly filled. The proportion of calamine to the copper varies according to the richness of the former, but is generally as three to two. The copper must be dispersed through the composition of calamine and coal, and the whole must be covered with more coal till the crucibles are full. The crucibles thus filled are to be placed in a furnace sunk in the ground, the form of which furnace is that of the frustum of a hollow cone. At the bottom of the furnace, or greater basis of the frustum, is a circular grate, or iron plate. This plate is covered with a coat of clay and horse-dung to defend it from the action of the fire, and pierced with holes, through which the air maintaining the fire passes. The crucibles stand upon the circular plate, forming a circular row with one in the middle. The fuel is placed betwixt the crucibles, and is thrown into the furnace at the upper part of it, or the lesser basis of the frustum. To this upper part or mouth of the furnace is fitted a cover made of bricks or clay, kept together by bars of iron, and pierced with holes. This cover serves as a register. When the heat is to be encreased, the cover is to be partly or entirely taken off, and a free draught is permitted to the external air, which passes along a vault under ground to the ash-hole, through the holes in the circular grate or plate, betwixt the crucibles, and through the upper mouth along with the smoke and flame into an area where the workmen stand, which is covered with a large dome or chimney through which the smoke and air ascend. When the heat is to be diminished, the mouth of the furnace is to be closed with the lid, through the holes in which the air, smoke, and flame pass. The crucibles are

Although zinc be only a ſemi-metal, and conſequently not ductile, and although metallic mixtures be generally leſs ductile than the pure metals of which they are compoſed, zinc ſeems to be an exception to this rule in its combination with copper; for it has the property of uniting with that metal in a large proportion, as of a third, or a fourth, without ſenſibly diminiſhing the ductility of the copper. But as this property is quite peculiar to zinc, it is evident that it is neceſſary, in order to make good braſs, that the copper and zinc be, each of them, in their greateſt purity.

If ſuch zinc as is procured in the ſmelting of ores be melted with copper, as in ſome mixtures commonly uſed, we might indeed obtain a very fine-colored braſs, but it would be brittle and unmalleable. It would only be a mixture of that kind called *tombacs*, becauſe this zinc is never very pure. *See* ZINC.

This inconvenience is avoided in making braſs, by a kind of cementation with the ore of zinc, which is lapis calaminaris. This proceſs is performed in the following manner.

A cement, compoſed of one part and a half of good lapis calaminaris and powder of charcoal triturated together, and moiſtened with water, is put into an earthen pot or crucible. Then one part of very pure copper beat into

to be kept red-hot during eight or ten hours, and in ſome places much longer, even ſeveral days, according to the quality of the calamine; during which time the zinc riſes in vapor from the calamine, unites with the copper, and renders that metal fuſible by conſiderably leſs heat than it is alone. To render the metal very fluid, that it may flow into one uniform maſs at the bottom, the fire is to be encreaſed a little before the crucibles are taken out for the pouring of the fluid metal into moulds. From ſixty pounds of good calamine and forty pounds of copper, ſixty pounds of braſs may by this proceſs be obtained, notwithſtanding that a conſiderable quantity of zinc is burnt and diſſipated during the operation; as we may learn from the blue flame round the mouths of the crucibles and furnaces, from the flowers of zinc which adhere to the inner ſides of the furnace, and from the blue color communicated to the crucibles. The quantity of braſs obtained has been conſiderably augmented ſince the introduction of the method now commonly practiſed of uſing granulated copper, by which a larger ſurface of this metal is expoſed to the vapor of the zinc, and conſequently leſs of that vapor eſcapes. For the granulation of the copper, a cylindrical wooden reſervoir is made, four or five feet deep, in which a circular braſs or copper bottom may be raiſed or lowered, by means of a chain. This reſervoir is covered with a copper lid, in the middle of which is a hole half a foot in diameter, intended to receive an iron ladle pierced with holes, and coated with clay. The reſervoir being filled with water, the melted copper is poured through the holes in the ladle into the water; where it is broken by its fall into ſmaller drops or grains, is rendered ſolid by the cold water, and is collected in the moveable bottom, which is afterwards to be raiſed by the annexed chain, that the granulated copper may be taken out.——The above is the proceſs generally employed for making braſs. But to make the finer and more malleable kinds of braſs, beſides the choice of pure calamine and pure copper, ſome manufacturers cement the braſs a ſecond time with calamine and charcoal, and ſometimes add to it old braſs, by which the new is ſaid to be meliorated.

Braſs is brittle when hot, but is ſo ductile when cold that it may be drawn into very fine wire. Its beautiful color, its hardneſs, its malleability, its fuſibility, by which it may be eaſily caſt into moulds, and its quality of being leſs ſubject to ruſt or verdigriſe than copper, render it fit for the fabrication of many utenſils.

plates,

plates, is placed over the cement, and the whole is covered with charcoal dust. The crucible is then closed, and is heated only enough to make it gradually become red. When the flame of the coals has acquired a cupreous color, an iron rod is introduced into the crucible, to try if the copper be melted under the cementing powder. If that be the case, the action of the fire is moderated, and in a few minutes the crucible is taken out.

When it is cooled, the copper is found to have become yellow, and to have received an augmentation of a fourth, and sometimes of a third of its weight, and is nevertheless very malleable.

This process is, as we see, a kind of cementation, in which the zinc is raised from its ore in vapors, and combines with the copper. This method is advantageous, principally because the other metallic matters, and particularly the iron, from which lapis calaminaris is seldom free, do not rise in vapors, and consequently cannot combine with the copper.

In order to effect this purpose more certainly, the cementing powder may be mixed up with clay into a paste; which being put in the bottom of the crucible, is to be covered with plates of copper and charcoal powder, proceeding as is directed above. The copper, penetrated by the vapors of the zinc which pass through the paste, melts upon the surface of the paste, and does not mix with the other metals, which always alters the color and ductility of the brass. These processes are from M. Cramer.

The advantages of converting copper into brass are, that its weight is augmented one fourth part; that its color is changed to one more agreeable, as it approaches the color of gold; that it is more fusible; and lastly, that it is less subject to rust, because zinc is less susceptible than copper of being altered by the action of air and of water.

Although zinc be fixed to a certain degree in brass by the adhesion it contracts with the copper, yet when brass is melted and exposed to a violent fire during a certain time, the zinc dissipates in vapors, and even flames away, if the heat be strong enough; and if the heat lasts long enough, all the zinc will be evaporated and destroyed, so that what remains is copper.

Copper, or copper converted into brass, or in any other form, but particularly when penetrated by any salts and reduced into verdigrise, produces always, when taken internally, the most troublesome consequences, and becomes a poison. For this reason it is dangerous to use copper utensils and vessels for the purpose of cookery, and in many places they beg n to be disused.

For the same reason also, none of the preparations of this metal are ever employed medicinally by prudent physicians. It appears, however, to enter into the composition of a remedy much used, the *Lilly of Paracelsus*, or *Tincture of Metals*: but in fact, it is certain that the spirit of wine, employed for the preparation of this medicine, dissolves nothing of the calx of copper, or of the other calxes of metallic substances digested in it. Mr. Beaumé convinced himself of this fact by a most accurate examination of the *Lilly of Paracelsus*.

The best remedies for persons poisoned by verdigrise are, mild, watery, mucilaginous, and oily drinks, given quickly and copiously, which ought to be immediately succeeded by evacuants to carry off the poison as fast as is possible.

The use of copper then in medicine is confined to external applications. It is stimulant, tonic, and detersive. Verdigrise enters into the ungentum Egyptiacum, into several plasters, the collyrium of Lanfranc, and the green balsam of Metz. A blue water for the eyes is made with copper and sal ammoniac, which is called *Celestial water*.

CXX. BREAD. The grains of all vegetables are almost entirely composed of substances very proper for the nourishment of animals; and amongst grains those which contain a farinaceous matter are the most agreeable and most nutritive.

Man, who appears to be designed by nature to eat of all substances which are capable of nourishing him, and still more of vegetables than animals, has, from time immemorial, and in all parts of the earth, used farinaceous grains as the principal basis of his food: but as these grains cannot be without difficulty eaten by men in their natural state, this active and intelligent animal has gradually found means not only to extract the farinaceous part, that is, the only nutritive part of these grains, but also to prepare it so that it becomes a very agreeable and wholesome aliment, such as the bread we now generally eat.

Nothing appears so easy at first sight as to grind corn, to make a paste with the flour and water, and to bake this paste in an oven. They who are accustomed to enjoy the advantages of the finest human inventions, without reflecting on the labor it has cost to compleat them, think all these operations common and trivial. However, it appears very certain, that for a long time men no otherwise prepared their corn than by boiling and forming compact, viscous cakes, not very agreeable to the taste, and of difficult digestion, before they were able to make bread of good taste and quality, as we have now. It was necessary to invent and compleat ingenious machines for grinding corn, and separating the pure flour with little trouble and labor; and that inquiries, or rather some happy chance, which some observing person availed himself of, should discover that flour mixed with a certain quantity of water is susceptible of a fermentation, which almost entirely destroys its viscidity, heightens its taste, and renders it proper to make a light bread, very agreeable to the taste, and of easy digestion.

This essential operation, on which the good quality of bread depends, is entirely of the province of chemistry. It would add to the honour of the ancient cultivators of chemistry, to attribute to them so useful and important a discovery; but unhappily it is too probable that they had no share in it. The ancient chemists were engaged in other pursuits than that of bread and other common objects. They hoped to make gold; and what is bread in comparison with gold?

However that be, to the fortunate invention of raising the paste before baking we owe the perfection of the art of making bread. This operation consists in keeping some paste or dough, till by a peculiar spirituous fermentation it swells, rarefies, and acquires a smell and taste quick, pungent, spirituous, somewhat sour, and rather disagreeable. This fermented dough is well worked with some fresh dough, which is by that mixture, and moderate heat, disposed to a similar, but less advanced fermentation than that above-mentioned. By this fermentation the dough is attenuated and divided, air is introduced into it,

which being incapable of disengaging itself from the tenacious and solid paste, forms in it small cavities, raises and swells it: hence the small quantity of fermented paste which disposes the rest to ferment, is called *leaven*, from the French word *lever*, signifying to raise.

When the dough is thus raised, it is in a proper state to be put into the oven, where, while it is baked, it dilates itself still more by the rarefaction of the air, and of the spirituous substance it contains, and it forms a bread full of eyes or cavities, consequently light, and entirely different from the heavy, compact, viscous, and indigested masses made by baking unfermented dough,

The invention of beer, or wine of grains, furnishes a new matter useful in the making of bread. This matter is the froth which forms upon the surface of these liquors during fermentation. When it is mixed with dough, it raises it better and more quickly than ordinary leaven. It is called *yeast* or *barm*. By means of this the finest, lightest bread is made. It often happens that bread made with leaven dough has a sourish and not agreeable taste, which may proceed from too great a quantity of leaven, or from leaven in which the fermentation has advanced too far. This inconvenience does not happen to bread made with yeast; because the fermentation of this substance is not too far advanced, or because more attention is given to that finer bread.

It may be asked, why, since dough is capable of fermenting spontaneously and singly, as we see from the leaven, a substance is added to dispose it to ferment. The true reason is, that all the parts of a fermenting substance do not ferment at the same time, nor to the same degree; so that some parts of this substance have finished their fermentation while others have not yet begun. The fermentable liquors which contain much sugar, as hydromel, and must of wines, give proofs of this truth; for, after these liquors have become very vinous, they have still very distinctly a saccharine taste: but all saccharine matter is still susceptible of fermentation; and, in fact, if vinous hydromel, or must, or even new beer, be distilled, so that all their ardent spirit shall be separated, and the residuums diluted with water, we shall see a second fermentation take place, and a new quantity of ardent spirit formed.

The same thing precisely happens to dough, and still more sensibly, from its viscosity and want of fluidity; so that if it be left to ferment alone, and without the help of leaven, as the fermentation proceeds very slowly and successively, the parts which ferment first will have become sour and vapid before all the rest be sufficiently attenuated and changed, by which the bread will acquire a disagreeable taste.

A mixture of a small quantity of leaven with dough effectually prevents this inconvenience; because the effect of this leaven, and of all fermenting substances, is to dispose to a similar fermentation all matters capable of it, with which it is mixed; or rather, by means of leaven, the fermentation of all the parts of such substances is effected more nearly at the same time.

Bread well raised and baked differs from unfermented bread, not only in being less compact, lighter, and of a more agreeable taste, but also in being more easily miscible with water, with which it does not form a viscous mass, which circumstance is of great importance in digestion.

CXXI. BRONZE. Bronze is a compound of copper and tin, to which sometimes other metallic substances, particularly zinc, are added.

Bronze

Bronze is brittle, hard, and ſonorous. It is employed for various uſes, as for making bells, cannons, and ſtatues; and the proportions of the component metals are varied to ſuit the ſeveral uſes to which it is applied.

The compound of copper and tin has a greater than the intermediate ſpecific gravity. Two ounces of a metal compoſed of four-fifths of pure copper, and one fifth of pure tin have ſeven grains and the tenth of a grain more of ſpecific gravity, than the ſame quantities of theſe two metals not allayed have. (k) This proves that in the union of copper and tin there is a penetration of parts; that is, that one metal enters into the pores of the other. Perhaps even this effect is reciprocal.

Many chemiſts, and particularly Glauber and Becker, have a long time ago remarked, that the ſpecific gravities of metallic allays differed more or leſs from what they ought to be, if there were no penetration, and that ſometimes the effect is contrary. But lately this matter has been treated with more preciſion. Several good chemiſts, ſuch as Eiſporn, Hahn, Krafft, and Gellert, have given reſults of well conducted experiments on this ſubject. *See Gellert's Metallurgic Chemiſtry. See the words* ALLAY, GRAVITY (SPECIFIC).

Mr. Tillet, member of the Royal Academy of Sciences, obſerves, in his Memoir concerning the ductility of metals, that when the mixture of copper with tin is made in the proportions above-mentioned, the color of the copper is entirely annulled and covered by that of the tin, although the quantity of copper be four times the quantity of tin. This ſingular effect cannot be underſtood without admitting a total change in the ſize and diſpoſition of the pores of the compound metal; which conſequently is a new proof of the reciprocal penetration of the two metals.

As tin is leſs ſenſible to the action of ſalts, of moiſture, and of the air, than copper, it is alſo leſs liable to ruſt: hence bronze is leſs apt to be covered with verdigriſe than pure copper is. This is one reaſon why this allay is uſed for cannons, ſtatues, and works expoſed to the air and weather.

The greater fuſibility of bronze than of copper is alſo an advantageous property, and much facilitates the caſting of large works, as ſtatues, bells, and cannon.

Laſtly, a phenomenon worthy of attention is, that tin, though greatly ſofter and leſs ſonorous than copper, nevertheleſs renders this metal, by being allayed with it in a proper proportion, more hard and more ſonorous: hence this allay is uſed for bells.

The operation by which large works of bronze are caſt is ſufficiently ſimple. For this purpoſe a brick furnace is uſed, nearly of the ſhape of an oven for baking bread. The floor of this furnace is concave, and conſiſts of a compoſition of ſand and clay. In this hollow floor the metals to be fuſed are put. The furnace has three openings.

The firſt is a lateral mouth, at which enters the flame of wood placed in a ſecond furnace on one ſide of the firſt; the ſecond opening is a chimney placed on the ſide oppoſite to the mouth, by means of which the flame is drawn over

(k) The author means, I ſuppoſe, that a metallic maſs, weighing two ounces, compoſed of four-fifths of copper and one fifth part of tin, weighs, in water, $7\frac{1}{10}$ grains more than the ſame quantities of theſe two metals would together weigh, in water, if not allayed.

the

the metal. The third opening is a hole which is opened and ſhut at pleaſure, through which the inner part of the furnace may be occaſionally inſpected, that the ſtate of the metal may be obſerved. When the metal is in the ſtate required, a fourth opening is then uncloſed, communicating with the hollow floor, and through which the melted metal flows by channels into the moulds prepared to receive it.

CXXII. BRYONY. *(l)*

CXXIII. BURDOCK. *(m)*

CXXIV. BUTTER. Butter is the fat, oily, and inflammable part of milk. This kind of oil is naturally diſtributed through all the ſubſtances of the milk, in very ſmall particles, which are interpoſed betwixt the caſeous and ſerous parts, amongſt which it keeps itſelf ſuſpended by a ſlight adheſion but without being diſſolved. It is in the ſame ſtate in which oil is, in emulſions; hence the ſame whiteneſs of milk and emulſions, and hence by reſt the oily parts ſeparate from both theſe liquors to the ſurface, and form a cream. *See* EMULSION.

When butter is in the ſtate of cream, its proper oily parts are not yet ſufficiently united together to form a homogeneous maſs. They are ſtill half-ſeparated by the interpoſition of a pretty large quantity of caſeous and ſerous particles. The butter is compleatly formed by preſſing out theſe heterogeneous parts by means of continued percuſſion. It then becomes an uniform ſoft maſs.

Freſh butter, which has undergone no change, has ſcarcely any ſmell; its taſte is mild and agreeable; it melts with a weak heat, and none of its principles are diſengaged by the heat of boiling water. Theſe properties, together with that of not inflaming but with a heat greater than that of boiling water, capable of decompoſing it, and reducing it to vapors, prove that the oily part of butter is of the nature of the mild, fat, and fixed oils obtained from many vegetable ſubſtances by expreſſion. *See* OILS (SWEET EXPRESSED).

The half fluid conſiſtence of butter, as of moſt other concrete oily matters, is cauſed by a conſiderable quantity of acid, united with the oily part: but this acid is ſo well combined, that it is not ſenſible while the butter is freſh, and has undergone no change; but when it grows old, and undergoes ſome kind of fermentation, then the acid is diſengaged more and more; and this is the cauſe that butter, like oils of the ſame kind, becomes rancid by age.

The acid of butter is more quickly and ſenſibly diſengaged by fire. If butter be expoſed to a degree of fire ſtrong enough to make it ſmoke, vapors are exhaled from it inſupportably acrid, which draws tears from the eyes, and excite coughing, as may be daily obſerved in kitchens. Theſe vapors are nothing elſe than the diſengaged acid. The remaining part of the butter after this operation has a ſtrong taſte, very different from its former mildneſs; becauſe the part of the acid which is not exhaled is become ſenſible and half-diſengaged by

(l) BRYONY. From two ounces of this plant Neuman obtained by water ten drams of gummy extract, and from the ſame quantity he obtained by ſpirit two drams two ſcruples and a half of reſinous extract.

(m) BURDOCK ROOT. From 16 drams of this root Neuman extracted by water 7 drams 52 grains, and from an equal quantity of it by ſpirit he extracted 5 drams and 50 grains.

the action of the fire. The same thing precisely happens when butter is distilled in a retort.

To decompose butter by distillation, a much greater heat than that of boiling water must be applied to it: acid vapors are then raised of considerable volatility and acrimony. These vapors are accompanied with a small portion of oil, which being that part which is mostly deprived of its acid, does not congeal; then a second oil of a red color passes, which congeals when cold, and which becomes more and more thick as the distillation advances. Lastly, a small quantity of charry matter remains in the retort, which in an open fire can be scarcely burnt entirely, and reduced to ashes.

If the congealed oil in the receiver be again distilled, more acid and fluid oil are obtained. Thus the whole of it may be reduced into acid and fluid oil by repeated distillations.

The acid obtained is accompanied with phlegm, particularly at first, and with a portion of oil united with it, which it renders soluble in water, and to which it partly owes its volatility. It is owing to this oil that the acid has the empyreumatic smell of burnt butter.

There are many essential remarks to be made upon this analysis of butter by distillation; because it presents exactly the same phenomena as the analysis of all other concrete oily matters of the same kind, such as wax, suet, cacao, butter, sperma-ceti, and may be considered as a specimen of the decomposition of all these matters.

First, it is necessary that these distillations should be made slowly, and with the precise degree of heat necessary for continuing a moderate distillation; because when the distillation is too much hurried, the acid has not time to separate itself, and the concrete oily matter passes almost entirely into the receiver without suffering any decomposition: but whatever management be employed, a considerable part of this half-decomposed matter always passes, which must be subjected to future distillations in order to reduce it to fluid oil.

Secondly, when the distillation is too much hurried, the acid passes in white sensible vapors from the quantity of oil united with it. For the same reason, towards the end of the distillation, when the fire must be raised, the acid always passes in this form of white sensible vapors.

Thirdly, at each distillation, made of butter, or of its congealed oil, there is always a portion of oil entirely decomposed; and thus the quantity continually diminishes, and sensibly.

This quantity of entirely decomposed oil is proportionable to the quantities of phlegm acid, charry residuum, or earthy phlogisticated matter, which are obtained at each distillation, and are the proximate principles of the oil. This remark is applicable to the distillation of any oil. *See* OIL.

We ought also to observe in general upon this analysis of butter, that this matter, although derived from animal bodies, does not yield a particle of volatile alkali; neither does the fat of animals; which proves that these substances are not assimilated to other animal substances, all which, when decomposed, furnish volatile alkali, without excepting the oils obtained from these substances.

Butter is constantly used in food, from its agreeable taste; but to be wholesome, it must be very fresh, and free from rancidity, and also not fried or burnt;

burnt; otherwise its acrid and even caustic acid being disengaged, disorders digestion, renders it difficult and painful, excites acrid, empyreumatic belchings, and lastly, introduces much acrimony into the blood. Some persons have so delicate stomachs, that they are even affected with these inconveniences by fresh butter and by milk. *See* MILK. This observation is also applicable to oil, to fat, to chocolate, and in general to all oleaginous matters.

CXXV. BUTTER *of* ANTIMONY. Butter of antimony, called by some chemists the *glacial oil of antimony*, is composed of marine acid united with the reguline part of antimony.

This is one of the combinations which cannot be made directly; that is, by the application of pure and liquid marine acid to the regulus of antimony; for in this manner the marine acid, however strong, dissolves none, or almost none, of the regulus: but when the acid is in its highest degree of concentration, reduced almost to dryness, as it is in several combinations, and when the body to which it is united has a less strong affinity to it than the regulus of antimony has, then it quits that body to unite with the regulus, and forms the butter of antimony.

Marine acid united with mercury has all the above-mentioned conditions; wherefore butter of antimony may be made by mixing together corrosive sublimate and regulus of antimony, both well powdered, and by applying a certain heat and distillation.

Lemeri, the most exact of the operators who have written, says, that the best proportion of corrosive sublimate and regulus of antimony is sixteen parts of the former to six parts of the latter. He observes, that this mixture frequently becomes very hot, some time after it has been made. This heat proceeds from the re-action of the two matters upon each other even without fire.

To proceed to the distillation of butter of antimony: this mixture must be put in a retort of convenient size, the neck of which ought to be large and short; this retort is to be placed in a furnace with a sand-bath; a receiver is to be luted, and the distillation is to be carried on at first by a gentle fire, which is to be encreased as more heat becomes necessary to continue the operation; a heavy liquor rises, which congeals in the receiver when it cools: this is the butter of antimony. The operation is stopped when it appears that it cannot be continued without a great encrease of heat, by which fluid mercury would be distilled instead of butter of antimony.

If then it be required to obtain this mercury, which is a very pure mercury, revived from corrosive sublimate, before the fire is encreased, it is proper to remove the receiver, and apply another containing some water.

It is evident, that as the marine acid only unites with the regulus of antimony by disengaging itself from the mercury of the corrosive sublimate, this latter metal ought to appear in its proper fluid form; but as it is less volatile than the butter of antimony, it does not rise till this has passed, and the fire be encreased.

Butter of antimony may also be made by using antimony itself instead of its regulus; because the acid of corrosive sublimate attacks as easily the regulus of antimony in the antimony itself, although it be there united with sulphur, as when it is pure: but it is evident, that in this case more antimony must be used, than the requisite quantity of regulus in the preceding operation. Lemeri

 observes.

observes, that twelve parts of antimony are necessary for sixteen parts of corrosive sublimate.

When butter of antimony is made by this latter method, it more readily congeals, and is more solid than when made with the regulus.

Mr. Baron, in his notes on Lemeri's Chemistry, says, that this proceeds from the greater quantity of acid contained in the butter made with the regulus than in that made with antimony. This matter would require a particular examination.

However that may be, a part of this butter made with antimony always congeals in the neck of the retort, and is frequently accumulated there in sufficient quantity to block up the passage, by which means the confined vapors may occasion an explosion. This inconvenience is prevented by applying a hot-coal near the neck of the retort, by which the butter is melted, and made to flow into the receiver.

It is evident, that when the butter of antimony is made with antimony, if the distillation be continued after the butter has passed, we shall not then obtain fluid mercury, but a combination of mercury with the sulphur of the antimony, that is, a cinnabar will be sublimed. This is called the *cinnabar of antimony*. *See* MERCURY, SULPHUR, *and* CINNABAR.

This cinnabar makes its appearance towards the end of the operation by red vapors. As soon as these are seen, the receiver ought to be changed.

The butter of antimony made by either of these operations, especially by the latter, is generally rendered more or less impure by some fluid mercury, or by some cinnabar, which are raised along with it: but it is easily purified from these extraneous substances by a second distillation with a gentle heat, when it rises very white and pure. This second distillation, as all other repeated distillations and sublimations for the purifying of substances, is called *rectification*.

Sweet sublimate, *mercurial panacea*, and *white precipitate*, are also mercurial combinations with marine acid; and, like the corrosive sublimate, are capable of being decomposed by means of regulus of antimony, and of forming with it kinds of butter of antimony. But Lemeri observes, that these butters are less caustic than that made with corrosive sublimate; undoubtedly because these mercurial compounds contain less marine acid.

Lastly, butter of antimony may be made with *luna cornea*, which is a combination of silver with very concentrated marine acid, which is nearly in the same state as it is in corrosive sublimate, (*see* LUNA CORNEA); because the marine acid has less affinity with silver than with regulus of antimony. This butter is called the *lunar butter of antimony*.

Butter of antimony then contains a very concentrated marine acid, which is not so intimately engaged with the regulus of antimony as to lose all its properties; hence we may account for the property which the butter of antimony has of attracting moisture from air, and for its causticity; for it is strongly corrosive, and is applied, like lapis infernalis, to ulcers and to carious bones. *See* CAUSTICITY.

This metallic salt has been called *butter*, from its consistence, which is nearly the same as that of butter, and from the facility with which it melts with a very gentle heat.

Butter

Butter of antimony ought to be classed amongst the salts which are at once crystallizable and deliquescent; for however confused the mass seems after distillation, it is in fact a heap of very small crystals.

By the operation of butter of antimony, and its properties, several essential properties of the marine acid and of regulus of antimony are discovered.

First, although the marine acid has a great affinity with this semimetal, it cannot dissolve it, but when highly concentrated. This phenomenon is analogous to those presented by the marine acid with mercury and with silver, to both which it has a great affinity, but which it cannot dissolve unless it be very highly concentrated, or applied to them when their aggregation is broken; as we see by the operations of making *white precipitate*, *corrosive sublimate*, *luna cornea*, and of the *concentrated parting*. See *all these words*.

Secondly, the property which the butter of antimony has of not being decomposed by fire alone; as the metallic salts are which contain the vitriolic and nitrous acids, depends on the great adhesion which the marine acid contracts with the regulus of antimony, as it generally does with other metallic matters, and on its property of volatilizing them, or carrying them along with it in distillation; which we see happens in corrosive sublimate, luna cornea, smoking spirit of Libavius, and many other chemical operations, in which the most fixed metals are carried off by marine acid.

Thirdly, the butter of antimony is by the affusion of water changed in its nature, or rather is divided into two parts, one of which is perfectly dissolved by the water and another part is precipitated, being insoluble by water. The dissolved part contains its greatest possible quantity of acid, and the precipitated part contains the least possible quantity of acid. This latter part, when well washed, is called *mercurius vitæ*, or *powder of algaroth*. *See* POWDER *of* ALGAROTH.

Mr Beaumé pretends, that the powder of algaroth is improperly said to contain the least possible quantity of acid, since, by a sufficient lavation, he has been able to deprive it of every vestige of an acid.

Butter of antimony is soluble in nitrous acid; and this solution is made with great violence: afterwards, by evaporation of the acids, a white calx of antimony is formed, called *Bezoar mineral*. See *that word*.

CXXVI. BUTTER *of* ARSENIC. Butter of arsenic, called also *corrosive oil of arsenic*, is a combination of marine acid with arsenic. This combination is made by a process similar to that of the butter of antimony. According to Lemery, equal parts of butter of arsenic and corrosive sublimate ought to be pulverised, well mixed, and distilled together; by which a butyraceous liquor is obtained similar to butter of antimony in its external appearance.

When the distillation cannot be continued without considerably encreasing the fire, the receiver ought to be taken off, and another receiver, in which there is some water, adapted to the retort; then, upon raising the fire, fluid mercury may be obtained. *See* BUTTER *of* ANTIMONY.

This experiment shews, that the affinity of marine acid to arsenic is greater than to mercury. In this operation the mercury is revived from the corrosive sublimate.

It

It is evident that this butter of arsenic must be a most violent caustic. It ought not to be ever used, from its poisonous quality. *See* Arsenic.

It does not appear that this combination of marine acid with arsenic has been carefully examined by any chemist.

CXXVII. BUTTER *of* CACAO. Butter of cacao is an oily, concrete, white matter, of a firmer consistence than butter, or even than suet. This substance is extracted from the kernel of a fruit called *cacao*, with which *chocolate* is made.

As the butter of cacao is a true congealed oil, it cannot be obtained without a heat sufficient to melt it. The best method is to bruise the cacao, and to boil it in water. Almost all the superabundant and uncombined oil, which this substance contains, is liquefied, and separated from the parenchyma and extractive part; and as it is lighter, it swims on the surface of the liquor in which it is left to congeal, that it may more easily be taken off. This butter is generally mixed with some broken solid bits of the cacao fruit, from which it may be purified by melting with a very gentle heat without water, in a pretty deep vessel, and by keeping it thus melted, long enough for an entire separation of the matters to take place according to the specific gravities. By this method, a very white and pure butter of cacao may be obtained.

This oily concrete substance has a very mild taste; it has no aromatic smell; it does not rise in distillation without a heat superior to that of boiling water; by distillation it is partly decomposed; lastly, it does not flame, till it is sufficiently heated to be reduced into vapors. As these are precisely the properties of mild and fat oils obtained from vegetable and animal matters by expression only, the butter of cacao must be undoubtedly ranged in this class; and as it is concrete, it is analogous to other concrete oily matters of the same nature, such as wax, fat, butter of milk, &c. also it presents the same phenomena when decomposed and attenuated by distillation. For the reason of this *see* Butter.

Butter of cacao has quite the same medicinal properties as all the mild expressed oils. It is emollient and blunting when not rancid; it enters into the composition of pomatums. *See* Oils (Sweet Expressed).

CXXVIII. BUTTER *of* WAX. Butter of wax is nothing but half-decomposed wax; that is, wax deprived of a part of its acid by distillation. As this acid is the cause of the consistence of the oily part of wax, the reason is evident that the butter is softer than the wax itself. It has a strong smell, and, when left exposed to the air, it does not resume its consistence, in which it essentially differs from resinous matters. *See* Wax.

CXXIX. BUTTER *of* TIN. *Butter of tin* is a name given by some chemists to a combination of tin with the concentrated marine acid of corrosive sublimate.

Tin, as well as the regulus of antimony, has a stronger affinity to marine acid than mercury has. If then corrosive sublimate and tin, reduced to small parts, be mixed together, these two substances will act upon each other even without the application of heat, so that in time the mixture becomes moist, and attracts the humidity of the air. If these substances be distilled together immediately after their mixture, the corrosive sublimate is much more quickly decomposed

decomposed by the tin; the marine acid quits the mercury to unite with the tin, the greatest part of which it carries off along with it. In this distillation a kind of *marine salt with basis of tin* passes over. Part of this combination is in form of a liquor which smokes continually, even when cold. This is called the *smoking spirit of Libavius*. Another part is raised in a concrete form, which more particularly deserves the appellation of *butter of tin*, although it seems that several chemists give this name indifferently to the liquor or concrete matter, or to both of them at the same time. *See* SPIRIT (SMOKING) *of* LIBAVIUS.

CXXX. BUTTON. By the word *button* is meant the metal which is collected generally in a roundish mass at the bottom of a crucible after fusion, or which remains in the cupels after cupellation.

C.

CXXXI. CADMIA. The name of *Cadmia*, or *Calamine*, is given to several different substances. What is called the *Cadmia of the furnaces* is a matter which is sublimed when ores containing zinc, like those of Rammelsberg, are smelted. This cadmia consists of the flowers of zinc sublimed during the fusion, and adhering to the inner surfaces of the walls of furnaces, where they suffer a semi-fusion, and therefore acquire some solidity. So great a quantity of these are collected, that they form very thick incrustations, which must be frequently taken off. The name of *Cadmia of furnaces*, has also been given to all the soots and metallic sublimates formed by smelting in the great, although there certainly are great differences in these matters. *See* SMELTING *of* ORES.

Several authors call *Native* or *Fossil Cadmia*, a sort of stone or mineral, containing zinc, iron, and sometimes other substances. It is of a yellow or reddish colour, and is also called *Calamy*, *Calamine*, or lapis calaminaris. Both this mineral and the *Cadmia of Furnaces* are used for the preparation of brass. *See* BRASS.

Lastly, some chemists have given the name of *Fossil Cadmia* to a mineral containing arsenic, frequently bismuth, silver, and particularly the semi-metal, the calx of which being melted with vitrifiable matters, forms a beautiful blue glass. This mineral is better known by the name *Cobalt*, which only ought to be given to it, to avoid the confusion attending the application of the same name to different substances. *See* COBALT.

CXXXII. CALAMINE. *See* CADMIA, and ORES *of* ZINC.

CXXXIII. CALAMUS AROMATICUS (*n*).

CXXXIV. CALCINATION. The calcination of a body is, properly speaking, the exposing of it to the action of fire, to produce some change upon it.

The principal effects of fire in chemical operations are to carry off the volatile principles, and to separate them from the fixed, or to occasion the combustion of inflammable matters. Hence it follows that bodies are calcined either to

(*n*) CALAMUS AROMATICUS. The root of this plant has an agreeable flavour, and peculiar taste, both which are caused by an essential oil, of which two scruples were obtained by distillation from 16 ounces of the dry root. *Neuman.*

deprive

deprive them of ſome volatile principle, or to deſtroy their inflammable principle, and ſometimes for both of theſe purpoſes.

We have examples of the firſt kind of calcination, in expoſing calcareous earths and ſtones to the fire, to convert them into quicklime, which is effected by the entire evaporation of the watery principle contained in this kind of earth. *See* QUICKLIME.

The calcination of *Gypſum*, of *Alum*, of *Borax*, and of ſeveral other *Salts*, by fire, which deprives them of the water neceſſary for their cryſtallization; the roaſting of minerals, by which the fire carries off the ſulphur, arſenic, and other volatile contents; ought to be referred to the firſt kind of calcination.

We have an example of the ſecond kind of calcination, by expoſing imperfect metals to fire; by which they loſe their inflammable principle, their form, and metallic properties, and are changed into earthy matters called *Metallic Calxes*.

It is neceſſary to obſerve, that this ſecond calcination differs eſſentially from the firſt, as the changes produced by it upon imperfect metals are not effected by evaporation, but by decompoſition and deſtruction of their phlogiſton. It is therefore a *combuſtion*, and not a *volatiliſation* of their inflammable principle.

Hence it follows, that the firſt kind of calcination may ſucceed without the contact of air and in cloſe veſſels, although it is more quick and complete in open veſſels, from a property of air, by which it greatly accelerates the evaporation of volatile bodies. *See* AIR. But as the ſecond kind of calcination is a true combuſtion, like that of all inflammable bodies, it requires all the conditions neceſſary for combuſtion. and particularly the free acceſs of air. *See* COMBUSTION *and* CALXES (METALLIC).

There are many bodies, in the calcination of which an evaporation of volatile parts happens, and alſo a deſtruction or deprivation of their inflammable principle, although without any ſenſible combuſtion of this latter. Such particularly are all combinations of imperfect metallic matters with vitriolic and nitrous acids: when theſe bodies are expoſed to fire, their acid evaporates, and at the ſame time carries off with it their inflammable principle. We have examples of this kind of calcination in expoſing to fire *Martial Vitriol* and *Bezoard Mineral*.

As vitriolic acid, and ſtill more nitrous acid, deprive the imperfect metals of more or leſs of their phlogiſton even without fire, ſeveral of theſe metals, particularly iron, copper, tin, regulus of antimony, are reduced, after they have been diſſolved in theſe acids, to a ſtate ſimilar to that of calcination with acceſs of air; that is to ſay, they become earths, not poſſeſſed of metallic properties, which they cannot reſume without the addition of phlogiſton. Hence moſt chemiſts conſider acids as capable of calcining theſe metals, and they accordingly call earths of metals which have been dephlogiſticated by acids, without fire, *Calxes*.

Laſtly, nitrous acid, when engaged in a fixed alkali, that is, nitre having the property of inflaming when applied to a combuſtible ſubſtance with a red heat, and of making the phlogiſton of theſe bodies burn, becomes a very powerful agent for the calcination of many ſubſtances, and particularly of imperfect metals and charry matters. *See* NITRE. We have a very good example of this kind of calcination in the preparation of diaphoretic antimony.

This calcination of metals by nitre is effected partly by a dephlogistication similar to that by nitrous acid in humid solutions, and partly by combustion: which does not hinder it from succeeding without access of air, and in close vessels, from the peculiar property of nitre in this respect. See NITRE.

It is proper to observe, that certain preparations of gold and silver are improperly called calxes, because they are not truly calcined, no method being known by which they can be deprived of their phlogiston. See GOLD, SILVER, and METALS (PERFECT).

What is improperly called *Calx of Gold*, is nothing but gold reduced into very fine particles, either by amalgamation with mercury, or by its separation from other solvents. Most of these improper names, found in such numbers in chemistry, proceed from the ignorance of ancient chemists, and still more of alchemists, who all believed, for example, that they had processes for decomposing and calcining gold. Nothing is more equivocal than the pretended calcinations of perfect metals. We cannot, however, affirm its impossibility. Some facts even seem to make it probable; such as the destruction of gold in the focus of Thirshausen's great lens, an account of which is published by Homberg in the Memoirs of the Academy of Sciences, and the calcination of gold by long reverberation, in the manner of Isaacus Hollandus. But if the most simple and easy experiments of chemistry require frequent repetition to be sufficiently established, certainly these, which are exceedingly difficult and laborious, require great attention. See COMBUSTION, *for some essential observations regarding the second kind of calcination.*

CXXXV. CALXES *of* METALS. Metalic calxes are earths of metals deprived of their phlogiston, and consequently of their metallic properties.

All metallic substances, excepting gold, silver, platina and mercury, are susceptible of being deprived of their inflammable principle by several methods.

The first method is by burning their phlogiston in open air, and by a calcination, or rather a combustion similar to that of all other combustible matters. See CALCINATION *and* COMBUSTION.

The second method is by applying to metals acids capable of depriving them of their phlogiston, such as vitriolic acid, and particularly nitrous acid. This kind of calcination of metals is made in the humid way, and by solution. See SOLUTION.

The third method is by nitre, with which metallic matters may be detonated. This third method, which is composed of the two former, is the most efficacious and expeditious. See NITRE, *and* DETONATION *of* NITRE.

The earths of metals deprived of phlogiston by any of these methods have properties peculiar to each, concerning which the articles of the several metallic substances ought to be consulted; but they also have properties general and common to all. These are the following.

Not only calcined metals lose the characteristic properties of metals, but also the following changes are effected. The more perfectly metallic matters are calcined, the more they lose of their fusibility; so that very fusible substances, such as tin and regulus of antimony, are rendered by a perfect calcination, (that is, till they become very white) bodies absolutely infusible, and which may be classed

classed amongst those that are refractory. Hence it is proved that phlogiston is the principle of fusibility of metals.

In proportion as metallic substances lose their phlogiston, they become more fixed. This property is less sensible in metals, from their fixity, than in semimetals, all which are very volatile when in their metallic state, and the calxes or earths of which become exceedingly fixed, as we see very evidently from the example of diaphoretic antimony, which resists the most violent fire without the least loss, and which recovers all its volatility, if it be restored to its reguline state by addition of phlogiston. This proves that phlogiston is a principle essentially volatile, and that it communicates its volatility to certain bodies with which it is combined.

Metallic earths become less soluble in acids, and particularly in nitrous acid, by being deprived of phlogiston, as we may perceive from crocus martis when well calcined, from calxes of tin, of regulus of antimony, &c. Hence we are led to conclude, that the solubility of metallic substances by acids, and particularly by nitrous acid, depends on the intervention of phlogiston: for if calxes be reduced by adding phlogiston, the metals resulting from that reduction will then recover their solubility.

What we have said concerning the general changes produced by calcination of metallic matters, upon their fusibility, their fixity, and solubility, may also be applied to their opacity, their specific gravity, in a word, to all their metallic properties, which are always diminished so much more in metallic calxes, as they are more perfectly dephlogisticated. This seems to indicate, that if an entire and perfect calcination of metallic sustances could be effected, they would then have no metallic property, and perhaps they would not specifically differ from each other, and only be one and the same kind of earth. This is certain, that when the calcination of metals has been too long continued, their calxes become irreducible, or at least much more difficultly reducible; and this reduction is always made with loss, so that the quantity of metal originally calcined is never again obtained.

Although metallic calxes are essentially different from calx of stone or quicklime, they have nevertheless some similar properties, particularly those which relate to fixed and volatile alkalis. Thus, for example, fixed alkalis receive from metallic calxes the same causticity and properties as from quicklime; and volatile alkali may be separated from sal ammoniac by metallic calxes, and particularly by minium, as it may by quicklime; and it receives the same changes, that is, it becomes more penetrating, is always fluid, and cannot be reduced to a concrete state, when treated with a sufficient quantity of these matters. *See* Quicklime.

CXXXVI. CAMOMILE (*o*).

(*o*) Camomile. In the cup of the flowers of camomile resides a small quantity of blue essential oil. The flowers contain also a saline substance, which being extracted by decoction in wine, precipitated silver and mercury from nitrous acid, and these precipitates were different from luna cornea and corrosive sublimate. *Neuman.* Camomile flowers have been found by Dr. Pringle's experiments to possess eminently an antiseptic quality.

CXXXVII. CAMPHOR. Camphor is a vegetable, concrete, very volatile ſubſtance, and inflammable, as eſſential oils are; of a ſtrong ſmell, and eaſily ſoluble in ſpirit of wine.

From all theſe properties, camphor perfectly reſembles reſins; but on the other ſide, it eſſentially differs from them in this, that when expoſed to fire in cloſe veſſels, it is entirely ſublimed without ſuffering any decompoſition, and without leaving any reſiduum of coal or other matter. Although it has a ſtrong taſte, it has not the acrimony of eſſential oils: the moſt cauſtic alkalis do not act upon it: the vitriolic and nitrous acids diſſolve it, but without effervescence, heat, inflammation, ſcorching, or other ſenſible change, even when theſe acids are concentrated.

Nitrous acid diſſolves camphor without commotion; and the ſolution is clear and limpid. It is called *Oil of Camphor*. When it is mixed with too much water, the mixture becomes turbid and milky, becauſe the acid has a ſtronger affinity with water than with camphor. The camphor then quits the acid, and appears in white flocks, which ſoon precipitate to the bottom of the containing veſſel, their weight being encreaſed by ſome adhering acid. But when this acid is taken off by the water, the flocks of camphor riſe to the ſurface, and there float. When they are compleatly waſhed and dried, they are found to be camphor entirely ſimilar to what it was before this ſolution and precipitation. This is a manifeſt proof that camphor receives no change from the nitrous acid; which, however, of all acids, acts the moſt powerfully upon oily matters. *See* OILS (ESSENTIAL) *and* RESINS, *for the reſemblances and differences betwixt camphor and theſe ſubſtances.*

It follows from what has been ſaid concerning the properties of camphor, that this ſingular ſubſtance, although it has many of the eſſential properties of oils and reſins, is not, however, comparable to any of thoſe which are known, and forms a claſs apart. As, excepting its concrete ſtate, camphor approaches more to the nature of ether, preciſely by thoſe very properties in which it differs from oils, it is to be preſumed that this ſubſtance is analogous to ether, as Mr. Macquer conjectures in his Elements of Chemiſtry. *See* ETHER.

All the camphor which is ſold comes from India and Japan. It is procured from a kind of laurel called *Laurus Camphorifera*, great numbers of which grow in the iſland Borneo. A long time this tree was believed to be the only vegetable containing camphor; but ſeveral modern chemiſts, and particularly Mr. Cartheuſer, have diſcovered, that many aromatic plants, as thyme, roſemary, ſage, and almoſt all the labiated kind, contain a ſubſtance of the nature of camphor, which may be extracted, although in very ſmall quantities.

Camphor when firſt extracted from its tree is mixed with many impurities, and is then called *Rough Camphor*. The Dutch, who chiefly make a trade of it, purify it by ſublimation in glaſs matraſſes.

Camphor is uſed in medicine as ſedative and antiſpaſmodic. It ſucceeds well in many convulſions, and other nervous affections. This quality is common to it, and to all other ethereal, oily, volatile ſubſtances, ſuch as *Ether, Dippel's Animal oil, highly rectified Eſſential Oils; Muſk, Caſtor, Opium*, and other ſimilar ſubſtances. Hoffman has obſerved and commended, more than any other phyſician, the ſedative powers of camphor. This ſubſtance is alſo very ſucceſsfully

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used as a powerful antiseptic; and when dissolved in spirit of wine, is employed against gangrenes.

CXXXVIII. CANTHARIDES (p).

CXXXIX. CAP. The piece which terminates the top of a melting furnace is called the *Cap*. This piece has the form of an oblong dome. In one side there is a large oval door, intended for the introduction of a considerable quantity of coal at a time, because this kind of furnace consumes a great deal, and must be quickly supplied. The upper part of the cap is terminated by a tube or chimney, which may be lengthened at pleasure by the addition of other tubes adjusted to each other. *See* FURNACE (MELTING).

CXL. CAPITAL. The *Capital* or *Head* is the upper part of an alembic. *See* ALEMBIC.

CXLI. CAPUT MORTUUM. This is a Latin name given to fixed and exhausted residuums remaining in retorts after distillations.

As these residuums are very different, according to the substances distilled, and the degree of heat employed, they ought to be specified more particularly by adding a term denoting their qualities; as, for example, we might say, *Earthy Residuum*, *Charry Residuum*, *Saline Residuum*, &c. This method is more accurate and distinct, and is chiefly used by modern chemists.

CXLII. CARDAMOM (q).

CXLIII. CARDUUS (r).

CXLIV. CARMINE (s).

CXLV. CARNELIAN (t).

CXLVI. CASE-HARDENING (u).

(p) CANTHARIDES. These insects contain a very acrid resinous substance, six drams and two scruples of which were extracted by spirit of wine from four ounces of cantharides. The stimulating power of cantharides is caused by this substance, and not, as some imagine, by a volatile alkali, of which they yield less by analysis than some other animal substances, and none without the action of fire. *Neuman*.

(q) CARDAMOM. An ounce of the seeds of the lesser cardamom contain about a scruple of essential oil, by which their pungency and aromatic smell are caused, with fourteen grains of resinous extract, and forty-five grains of mucilage. *Neuman*.

(r) CARDUUS BENEDICTUS. From four ounces of the leaves of this plant may be obtained about 4½ drams of resinous extract by means of spirit of wine; or from the same quantity of leaves, about 6½ of mucilaginous extract by means of water. In the juice of this plant, after proper [illegible] and evaporation, saline crystals similar to nitre are formed. *Neuman*.

(s) CARMINE is a fine pigment prepared by dissolving cochineal in an alkaline lixivium, and precipitating the solution by alum. It consists, therefore, of the coloring matter of cochineal adhering to the earth of alum.

(t) CARNELIAN, *Carneolus*, or *Sardus*, is a semi-transparent reddish agate. *See* AGATE.

(u) CASE-HARDENING of iron is a superficial conversion of that metal into steel by the ordinary method of conversion, namely, by cementation with vegetable or animal coals. This operation is generally practised upon small pieces of iron wrought into tools, and instruments, to which a superficial conversion is sufficient; and it may be performed conveniently by putting the pieces of iron to be case-hardened, together with the cement, in an iron box, which is to be closely shut and exposed to a red heat during some hours. By this cementation, a certain thickness from the surface of the iron will be converted into steel, and a proper hardness may be afterwards given by sudden extinction of the heated pieces of converted iron in a cold fluid. *See* STEEL.

CXLVII.

CXLVII. CASSIA (*x*).

CXLVIII. CASTOR (*y*).

CXLIX. CAUSTIC (COMMON). Common caustic is a fixed alkaline salt, sharpened by quick-lime, and deprived of all moisture by drying and fusion. The alkali employed for this preparation is generally potash. A lixivium is made with quick-lime, like that of the soap-boilers, called soap-leys. *See* LIXIVIUM *of* SOAP BOILERS. This lixivium is to be evaporated to dryness in a copper or silver vessel. Afterwards the dry matter is to be put into a crucible, and exposed to fire till it flow like melted wax. Then it is to be poured into a bason, and quickly cut into pieces, while it is still hot and moist, and is to be speedily put into a glass bottle, well closed with a glass stopper.

An alkali thus treated is much more caustic than ordinary fixed alkali. It is also more fusible; and attracts the moisture of the air much more readily; for which reason it ought to be cut and put into bottles, while it is yet hot, otherwise it would become very soon moist.

This alkali when applied to the skin during half or three quarters of an hour, corrodes it, and forms a painful eschar, like that produced by burning. It is employed to open issues, which formerly were much used, but were afterwards almost abolished. They have since been brought again into frequent use; and justly, for they are serviceable by evacuating vicious fluids which resist other remedies. But at present common caustic is not much used for the opening of issues, because it occasions a quick and long pain. The common method at present is to make an incision with a knife, and to promote the suppuration by methods well known in surgery.

The causticity of common caustic must not be believed to proceed from a perfect drying and concentration of the alkali. This concentration does indeed augment its causticity; but we are no less certain, that independantly of that, alkalis treated with quick-lime are much more active and caustic, even when they are fluid, than any other alkalis. This is evident from the effects of the lixivium, or ley of soap-boilers, which almost instantaneously corrodes and destroys all animal matters. This causticity then is caused by some particular change produced upon alkalis fixed or volatile by quick-lime; which change probably consists in depriving them of some unctuous matter, which invelops and blunts their saline principle. *See* ALKALI (FIXED), ALKALI (VOLATILE), AMMONIAC SALT, SPIRIT (VOLATILE) *of* SAL AMMONIAC, LIXIVIUM *of* SOAP-BOILERS

CL. CAUSTIC (LUNAR). Lunar caustic, or *Lapis Infernalis*, is a caustic made by taking from lunar crystals all their water of crystallization by fusion.

To make the lunar caustic, crystals of silver are to be put into a Hessian crucible, which ought to be large in proportion to the quantity to be used, be-

(*x*) CASSIA. The fruit called *Cassia Fistularis* contains a sweet saline substance, soluble in water or in spirit of wine. *Neuman.*

(*y*) CASTOR. Two drams and a scruple of extract may be obtained from an ounce of castor by spirit of wine, or by water. By distillation with water, the peculiar smell of the castor is given to the water; hence we may probably infer that it contains an essential oil. By distillation with spirit of wine, none of this peculiar smell is given to the spirit. *Neuman.*

cause

cause a considerable swelling and frothing happens in the beginning of this fusion. The crucible is to be placed in a furnace which ought to draw little air, and surrounded by a very small quantity of lighted coals, because these crystals are very fusible, and too great heat would be prejudicial to the preparation of the lunar caustic. This matter is then to be very quickly liquified. In the beginning particularly, the heat ought to be moderate, otherwise a part of the matter might flow over the crucible, and deflagrate like nitre upon the coals, by which the silver would be reduced. While the ebullition gradually diminishes, the fire is to be encreased; and when the matter is brought to a perfect and tranquil fusion, it is to be cast into an iron mould previously heated and greased in its inner surface. The lunar caustic is there to be left till it is fixed and cold, and then it is to be put into a bottle with a glass stopper. The lunar caustic ought to be formed into small cylindrical pieces, like pencils, of about a line in diameter, and the surgeon who uses them puts them in a crayon or pencil case, to prevent his fingers being injured by touching them. The mould for the lunar caustic is so made as to give them that form. It consists of five or six hollow cylinders, placed vertically and parallel to each other, to which a gutter is adapted, by means of which the matter is poured into them. This mould is composed of two pieces which exactly fit each other, in each of which the same number of hollow semi-cylinders correspond to those of the other. By this disposition, when the lunar caustic is cast and cooled, it is obtained in entire cylinders, by separating the two pieces of the mould.

The lunar caustic must be poured as soon as it is in tranquil fusion, for that degree of heat is sufficient to carry off its acid, which may be observed to dissipate in fumes; and consequently, if it was left in the fire long after it is thus fused, it would lose some of its causticity, which it entirely owes to this acid.

The operation for lunar caustic shews two remarkable phenomena. The first is the black color assumed by the crystals of silver thus fused. I believe this color proceeds from a part of the phlogiston of the nitrous acid, which attaches itself to the silver superficially, and which always gives a black color to this and other white metals, such as mercury, lead, and bismuth, when it is thus united to them.

The other remarkable phenomenon is a certain symmetry of arrangement, or crystallization, which lunar caustic takes when it cools and becomes solid. If a pencil of lunar caustic be broken into pieces, its inner substance may be observed to be composed of needles or radii passing from the circumference to the center, much like the inside of the round ferruginous and sulphureous pyrites. This phenomenon is common to all bodies of a certain degree of simplicity of composition, which pass without agitation from a liquid to a solid state, and is a species of crystallization. Perhaps the same phenomenon occurs in many other neutral salts in which it has not yet been remarked. *See* CRYSTALLIZATION.

Lunar caustic ought to be made with tested silver. If silver allayed with copper be used, the crystals of silver ought to be well drained upon brown paper, by which they will be freed from the solution of copper, and will become white. This solution of copper in nitrous acid when dried is also caustic, but less so than lunar caustic. It also has the inconvenience of becoming moist in the air. *See* SILVER, CAUSTICITY, *and* CRYSTALS *of* SILVER.

CLI. CAUSTICITY. By this word is denoted a quality belonging to several substances, by the acrimony of which the parts of living animals may be corroded, and destroyed. Bodies which have this quality, when taken internally are true poisons. The causticity of some of these, as of *arsenic*, is so deadly, that even their external use is proscribed by prudent physicians. Several others, as *nitrous acid*, *lapis infernalis*, or *lunar caustic*, *common caustic*, *butter of antimony*, are daily and successfully used to consume excrescences, to destroy fungous flesh, to open issues, &c. They succeed very well when properly employed, and skilfully managed.

The causticity of bodies depends entirely on the state of the saline, and chiefly of the acid matters which they contain. When these acids happen to be at the same time much concentrated, and slightly attached to the matters with which they are combined, they are then capable of acting, and are corrosive and caustic. Thus fixed and volatile alkalis, although they are themselves caustic, become much more so by being treated with quicklime, because this substance deprives them of much fat or inflammable matter, which binds and restrains the action of their saline principle. (z) By this treatment then, the saline principle is more disengaged, and rendered more capable of action. Also, all combinations of metallic matters with acids, form salts more or less corrosive, because these acids are deprived of all their superabundant water, and are besides but imperfectly saturated by the metallic matters.

Nevertheless, some other circumstance is necessary to constitute the causticity of these saline metallic matters. For the same quantity of marine acid, which when pure and diluted with a certain quantity of water should be incapable of producing any harm, shall however produce all the effects of a corrosive poison when it is united with mercury in *corrosive sublimate*, although this sublimate shall be dissolved in so much water, that its causticity cannot be attributed to the concentration of its acid.

This effect is attributed by some chemists to the great weight of the metallic parts with which the acid is united. This opinion is very probable, since the causticity is nothing but its dissolving power, or its disposition to combine with other bodies; and this disposition is nothing else than attraction, which is one and the same thing as weight or gravitation.

CLII. CAWK. *(a)*

CLIII. CEMENT. All those powders and pastes are called *cements*, with which any body is surrounded in pots or crucibles, and which are capable, by help of fire, of producing changes upon that body. Hence the expressions *to cement*, and *cementation*.

The principal cements are the *royal cement*, which is used to separate silver from gold in the operation called *Concentrated Parting*; See PARTING

(z) The substance which quick-lime takes from alkaline salts, by which the dissolving power of these salts is encreased, is fixable air. *See* AIR (FIXABLE).

(a) CAWK is a white, very dense, sparry substance, unsoluble in acids, and fusible by fire. It is generally found in or near lead-mines. If an ounce or two ounces of cawk be thrown red-hot upon fifteen ounces of melted antimony, and the fusion continued about two minutes; a regulus weighing fifteen ounces will be obtained hard and white. *See Phil. Transf.* [illegible]. This experiment Dr. Lewis has frequently repeated with success.

(CONCEN-

TRATED) the cement for converting iron into steel (*see* STEEL); the cement for converting certain glass into porcelain (*see* GLASS *and* PORCELAIN); the cement for converting copper into brass; *see* BRASS.

Cements may be made of many various kinds, and for various purposes, by varying the materials of the compositions. Cementation is generally a very powerful method of producing changes upon bodies, or of forming combinations which could not otherwise be easily effected; because in this operation the active matters of the cement are in a state of dryness, are reduced into vapors, and assisted by considerable heat.

CLIV. CEMENT-COPPER. (*b*)

CLV. CENTAURY. (*c*)

CLVI. CERUSS, or WHITE LEAD. Ceruss is a kind of rust of lead which has been corroded and half-dissolved by vapors of vinegar. To make ceruss, leaden plates rolled spirally, so that the space of an inch shall be left betwixt each circumvolution, must be placed vertically in earthen pots of a proper size, containing some good vinegar. These leaden rolls ought to be so supported in the pots, that they do not touch the vinegar, but that the vapor of this acid may circulate freely betwixt the circumvolutions: these pots are to be covered, and placed in a bed of dung, or in a sand-bath, by which a gentle heat may be applied. The acid of vinegar, which very well dissolves lead, being thus reduced into vapors, easily attaches itself to the surface of these plates, penetrates them, and is impregnated with this metal, which it reduces to a beautiful white powder called *Ceruss*: when a sufficient quantity of it is collected on the surface of the plates, the rolls are taken out of the pots, and unfolded; the ceruss is then taken off, and they are again rolled up, that the operation may be repeated.

This management is very ingenious; because the plates of lead thus disposed present the greatest surface to the vapors of vinegar, while they occupy the least possible space.

As in this operation the acid of vinegar is overcharged with lead, this metal thus changed into ceruss, is not properly in a saline state; hence ceruss is not in crystals, nor is soluble in water: but a saline quality would render it unfit for painting, for which it is chiefly employed.

Ceruss ground and prepared for painting is called *white lead*. It is the only white hitherto found fit for painting in oil. The discovery of another white for this purpose is desirable, not only from its faults as a paint, but also from its injuring the health of persons employed in its manufacture, by affecting them with a severe disease, which lead and all its preparations frequently occasion, called the *colic of minerals*, or the *colic of painters*.

Ceruss, like the other preparations of lead, is drying, sedative, and lenient; as such it is employed, but only externally. It is an ingredient in many oint-

(*b*) CEMENT, or ZIMENT COPPER, is copper precipitated from vitriolic waters by iron. The name is derived, as is said, from a vitriolic water in Hungary called zimont.

(*c*) CENTAURY. The leaves of the lesser centaury contain a bitter substance soluble by water, or by spirit of wine. The green color of the plant resides in the resinous part, being extracted by spirit of wine, but not by water.

ments, plaisters, and other pharmaceutical preparations designed for external maladies.

As lead is much divided in ceruss, and is already penetrated with a certain quantity of acid of vinegar, its saturation with this acid may be easily compleated, by dissolving ceruss in distilled vinegar. Thus the lead is entirely reduced to a saline state. From this saturation a crystallizable neutral salt with metallic basis results, called *sugar* or *salt of lead* *See* SUGAR *of* LEAD.

CLVII. CERUSS *of* ANTIMONY. This name is given by some chemists to a pearl-colored matter, or white earth, which separates from the water with which diaphoretic antimony has been washed. It is the finest part of the white calx of antimony, which has been dissolved by the alkali of nitre formed in this operation. The peculiar earth of the alkali, some of which always separates after every calcination and solution, probably makes a part also of the ceruss of antimony. *See* DIAPHORETIC MINERAL.

CLVIII. CHALK. Chalk is a calcareous earth, found in form of friable stones, and therefore cannot be polished as marble and other hard calcareous stones may. Chalk is also found in powder. This substance has all the properties which characterize calcareous earths. *See* EARTHS (CALCAREOUS).

CLIX. CHALK (BLACK. (*d*).

CLX. CHARACTERS. Chemical characters are signs invented to represent the principal substances and operations in a concise manner. These signs ought to be understood, because they are used by many authors, and in tables of affinities. *See the* PLATES.

CLXI. CHEESE. Cheese is the mucilaginous or gelatinous part of milk. As the milk of all animals is a true emulsion, the cheese or caseous part of milk is an intermediate substance by which the oily or butyraceous part of this liquor is divided, and suspended in the serous part. Thus cheese is in milk what mucilage is in emulsions or milky juices of vegetables; but although it has some properties common with mucilages, it differs in other respects, particularly in its want of ductility, or its viscidity, and in its property of coagulating by heat and by acids.

Milk is composed of three very different substances, butter, cheese, and whey. These substances are only well mixed together, but not combined, since they are capable of a spontaneous separation or analysis: but this separation is not entire and exact, except it be procured by methods peculiar to each of these substances. *See* BUTTER, MILK, *and* WHEY.

To have cheese as pure as is possible, fresh milk, after the cream is well taken off, must be curdled by runnet, or by cream of tartar; the whey then must be well drained from it, and it must be frequently washed with much pure water.

If it be then exposed to distillation with a graduated heat, at first a phlegm arises which has a slight smell of milk or of cheese, without any marks of an acid or of an alkaline quality. This phlegm arises with the heat of boiling water;

(*d*) CHALK (BLACK); *humus nigra pictoria*; *atramentum sciffile*. This is a light, earthy, flakey substance used for drawing black lines on paper, and for mixing with oil or water for the use of painters. It is calcinable by fire to a reddish white earth. It is unsoluble by acids, and seems to be a bituminous slate. Wallerius says, that in Sweden, near Hunneberg, a black earth is found as diffusible in water as Indian ink.

and

and when the heat is encreaſed an oily and ſaline ſpirit ariſes. The ſaline part of this ſpirit is generally a volatile alkali. Afterwards a ſmall quantity of empyreumatic oil ariſes, which is at firſt fluid, and becomes more and more thick and fetid. Concrete volatile alkali alſo ariſes in this diſtillation; and at length when the retort is very red-hot, and nothing more riſes, a conſiderable quantity of coal remains. This coal is of that kind which cannot be burnt without very great difficulty.

From this analyſis of cheeſe, which reſembles the analyſis of all animal matters, this ſubſtance appears to be the moſt animaliſed part of the milk; for butter and whey furniſh other principles, and particularly much acid. We muſt, however, obſerve, that cheeſe made of the milk of frugivorous animals may furniſh acid, inſtead of volatile alkali. This difference depends perhaps on the nature of the aliments uſed by the animals from which the milk is taken, and alſo of their temperaments, diſpoſitions, and nature of their digeſtions; for, in general, the ſtate of the acid, and its greater or leſs diſpoſition to be transformed into volatile alkali, are very variable in the animal kingdom, particularly in thoſe animals which live only on vegetables, and in their milk, which ſtill more approaches a vegetable nature.

This matter, although very intereſting, has been much neglected by chemiſts. We find, in the Elements of Practical Chemiſtry, an analyſis of cheeſe produced from cows milk, and in that analyſis no mention is made but of an acid, which ſhews the variations that may happen in this matter. We wiſh it were examined as accurately as it deſerves; but for this purpoſe many experiments which require much time and favorable circumſtances ought to be made; which could not be done without having ſeveral cows of different ages, fed with different herbs and grains, at different periods from their having calved, and at different ſeaſons of the year. *See* MILK.

CLXII. CHEMISTRY. Chemiſtry is a ſcience, the object of which is to diſcover the properties of bodies by analyſis and by combination.

The advantages reſulting from this ſcience are too manifeſt and too numerous to require an enumeration in ſuch a work as this.

CLXIII. CHERT. (e)

CLXIV. CHRYSOLITE. (f)

CLXV. CINNABAR. Cinnabar is of two kinds; one is native, the other is artificial.

(e) CHERT, or CHERTZ; *petroſilex ſemipellucidus, lapis corneus, hornſtein of the Germans.* Chert is a ſemi-tranſparent ſtone of the ſiliceous kind. *See* its chemical properties under the article EARTH (VITRIFIABLE). It is generally leſs hard and of a coarſer texture, than common flints. Large quantities of chert are found in beds of limeſtone, as flints are found in beds of chalk, with this difference, that flints conſiſt of looſe nodules, and chert often forms large maſſes of the rock. They are uſed as grinding ſtones for grinding calcined flints, and other hard ſubſtances, but have too ſmooth and cloſe a texture for the grinding of corn.

(f) CHRYSOLITE is a pellucid, yellowiſh-green ſtone or gem, the ſixth in hardneſs from diamonds, yet ſuſceptible of impreſſion from a file. By fire it ſuffers no other change than loſs of color. It is probably a ſpecies or variety of topaz. Its chemical properties *ſee* under the article EARTH (VITRIFIABLE). This gem may be imitated by adding twenty grains of crocus martis to two ounces of cryſtal-glaſs, and ſix ounces of minium.

Native cinnabar is a heavy and brittle mineral, of a very deep red color when it is in a lump, and consists of shining, needle-like, parallel striæ.

This mineral is composed of mercury and sulphur, as will be proved when we shall relate its analysis. It is, properly speaking, mercury mineralised by sulphur, or a true ore of mercury.

Cinnabar cannot be attacked in the humid way by any chemical agent. It is volatile; so that, when exposed to fire in close vessels, it is entirely sublimed, without suffering any decomposition. The sublimation may be repeated any number of times without any change upon the substance.

If cinnabar be exposed to the action of fire, with access of air, it is decomposed by the burning of its sulphur, and then the mercury disengages itself in vapors; but as these vapors are not easily to be collected, and as many of them would be lost by this method of decomposition with access of air, another method is employed of decomposing cinnabar in close vessels, by means of some substance to which sulphur has a greater affinity than to mercury. Many substances are known to be possessed of the quality required for this purpose.

Fixed alkalis, quicklime, calcareous earths, iron, copper, tin, lead, silver, bismuth, and regulus of antimony, have a greater affinity than mercury has to sulphur, and consequently are capable of decomposing cinnabar. Of these substances iron is found to be the most convenient, and is therefore most used for the decomposition of small quantities of cinnabar. When this decomposition is to be made, equal parts of filings of iron and cinnabar are to be well mixed together, and put into a retort, which is to be exposed in a furnace to a naked fire, or in a sand-bath so disposed that a sufficiently strong heat may be applied; a receiver containing water is to be adapted to the retort, and the distillation to be promoted. The mercury disengaged from the sulphur by means of iron is raised into vapors, most of which are condensed in the receiver, at the bottom of which, under the water, they appear changed into fluid mercury; a small part of the mercury remains much divided, and floats on the surface of the water in form of a black powder, which must be carefully collected, and mixed with the mass of fluid mercury, with which it easily incorporates; this mercury, which is then to be strained through closely woven linen, is very pure. It is called *mercury revivified from cinnabar*; and this reduction is called *revivification of mercury from cinnabar*. In the retort is found a mass composed of the iron employed, and of the sulphur of the cinnabar; or if, instead of iron, some other substance was employed, it would be found after the operation united with the sulphur. Thus if an alkali or calcareous earth has been employed, an earthy or alkaline liver of sulphur will be found. *See* SULPHUR.

By weighing the cinnabar employed in this process, and the mercury obtained by it, this mercury is found to be seven-eighths of the whole cinnabar. Thus in cinnabar seven parts of mercury are united with one part of sulphur.

From a knowledge of the constituent parts of cinnabar we may learn a method of composing an artificial cinnabar entirely similar to the natural. For this purpose, mercury and sulphur must be fused and triturated together till they unite well, and form a black body called *Ethiops mineral*. *See* ETHIOPS MINERAL. This Ethiops mineral is then to be sublimed; but we must observe, that the operation is attended with some difficulties; so that a beautiful and perfect cinnabar, in which the mercury and sulphur are exactly proportioned, cannot be obtained

obtained by the first sublimation. The first sublimate is always overcharged with sulphur, which gives it a black color. The reason of this is, that more sulphur is necessarily employed to make the ethiops mineral than is sufficient to form cinnabar: but by each subsequent sublimation some of that superfluous sulphur is separated, till at length, by five or six sublimations, it becomes entirely similar to native cinnabar. (g)

CLXVI. CINNABAR *of* ANTIMONY. An artificial cinnabar may also be obtained from the decomposition of corrosive sublimate by antimony. This operation is performed by mixing together and distilling these two compound substances. The marine acid of corrosive sublimate, which has a stronger affinity to regulus of antimony than to mercury, quits this latter substance to combine with the former, with which it forms a new compound called *butter of antimony*, that passes by distillation into the receiver. *See* BUTTER *of* ANTIMONY.

Also the mercury of the corrosive sublimate, being disengaged from its marine acid, unites with the sulphur of the antimony likewise disengaged from its regulus; and these two substances, thus united, are sublimed in form of cinnabar after the butter of antimony has been distilled: but although in this process the mercury is not previously united with the sulphur into an ethiops, the same superfluity of sulphur is perceived in the cinnabar produced by this as by the former operation; because the quantity of antimony necessarily employed for the compleat decomposition of corrosive sublimate, contains more than the requisite quantity of sulphur for the formation of perfect cinnabar with the quantity of mercury contained in the corrosive sublimate. This inconvenience is to be remedied by the method directed in the former process; that is, by repeating the sublimation till the cinnabar becomes perfect, and entirely similar to the native. It is called *cinnabar of antimony*, because its sulphur has been furnished by antimony.

The chief use of cinnabar is for painting. Although this body be composed of sulphur, the color of which is a light citron, and of mercury which is white as silver, it is nevertheless of an exceeding strong red color. Lumps of it are of a deep brown red, without brilliancy. But when the too great intensity of its color is diminished by bruising it and dividing it into small parts, (which is a method generally used to lessen the intensity of all colors) the red of the cinnabar becomes more and more exalted, flame-colored, and exceedingly vivid and brilliant. In this state cinnabar is called *vermilion*.

Cinnabar is often employed as an internal medicine. Hoffman greatly recommends it as a sedative and antispasmodic; and Stahl makes it an ingredient in his *temperant powder*. Other very intelligent physicians, and particularly Mr. Cartheuser, deny that cinnabar taken internally has any medicinal quality. Their opinion is grounded on the insolubility of cinnabar by any menstruum. This question concerning the utility of cinnabar taken internally cannot be decided without new researches and experiments. But cinnabar is certainly used

(g) Hoffman says that cinnabar may be produced without sublimation by shaking or digesting a little mercury with volatile tincture of sulphur, by which means the mercury imbibes the sulphur from the volatile spirit, and forms with it a deep red powder, the color of which is not inferior to that of ordinary cinnabar.

successfully

fuccefsfu'ly to procure a mercurial fumigation, when that method of cure is proper in venereal difeafes. For this purpofe cinnabar is burnt in an open fire on red-hot coals, by which the mercury is difengaged, and forms vapors, which being applied to the body of the difeafed perfon, penetrate through the pores of the fkin, and produce effects fimilar to thofe of mercury adminiftered by friction.

When fumigations of cinnabar are applied, the patient ought not to be expofed to breathe the vapors of the mercury and of the burning fulphur, which might injure him. *See* MERCURY *and* SULPHUR. (*h*)

CLXVII. CINNAMON. (*i*)

CLXVIII. CIVET. (*k*)

CLXIX. CLAY, *or* ARGILLACEOUS EARTH, is a particular kind of ftrong earth, confiderable banks of which are found almoft every where, at greater or lefs depths. The general properties and characteriftics of pure clay are:

1. This earth makes no fenfible effervefcence with acids, although it be capable of folution by acids, as we fhall fee.

2. Clay being moiftened with water, imbibes fome of that liquid, fwells, and mixes with it.

3. When it is mixed with no more than the neceffary quantity of water to reduce it to a moderately foft pafte, it is fo ductile as to be capable of being worked upon a potter's wheel, and of being formed in moulds. By thefe means veffels may be made of it which keep their form.

4. Clay is denfe, compact, and clofe. When its furface is rubbed with a polifhed body, it alfo becomes polifhed.

5. If it be expofed when moift to a gentle heat, it gradually dries and contracts; that is, its dimenfions become lefs; hence it is very apt to crack. (*l*) It retains moifture pretty ftrongly, and difficultly allows the laft portions of it to efcape.

6. If clay be heated much, and quickly, before it be perfectly dried, it burfts with loud noife from the effort made by the water rarefied and changed into vapor, to efcape from the parts of this tenacious earth which invelop it. Thus this burfting and cracking do not happen, if the clay expofed to heat contain water enough to render it foft; becaufe then the water finding much lefs refiftance from the clay, only feparates the argillaceous parts from each other, and efcapes with confiderable intumefcence.

(*h*) Some native cinnabars, according to Bruckman, (*Epiftol. Itiner.*) are fo hard, that they are polifhed, turned in a lathe, and wrought like marble.

(*i*) CINNAMON. From 16 oz. of the beft cinnamon fcarcely more than two fcruples and a half of effential oil can be obtained. This oil may be raifed by diftillation with water, but fcarcely with fpirit of wine. The whole tafte and flavor of cinnamon may be extracted by digeftion with fpirit of wine. *Neuman.*

(*k*) CIVET is an odoriferous unctuous animal juice, foluble in oils, but not in fpirit of wine, nor in water, even by means of fugar. *Neuman.*

(*l*) Dr. Lewis found from experiments, that pure clay foftened with water to a due confiftence to be worked upon a potter's wheel, contracted by drying [illegible] part of every dimenfion.

7. If

7. If pure clay, previously well dried, be exposed to a very violent fire, such for example, as the fire of a glass-house, it does not melt, and resists much more than sand does the action of fluxes and vitrifying matters. By fire its parts are only very strongly agglutinated; and the mass of clay thus calcined is called *baked clay*. During this baking it contracts in every dimension, and becomes as hard as flint, so that it is capable of striking fire with steel.

8. When clay has been thus baked by fire, it becomes no longer penetrable by water. If it be ground and levigated, it mixes with water as very fine sand does; that is, it does not form, as the crude clay does, a tenacious, ductile paste, fit to be turned on a potter's wheel.

9. Clay is entirely soluble in acids, and particularly in the vitriolic, with which acid it forms a vitriolic salt with an earthy basis, which is true alum. *See* ALUM.

10. Lastly, clay, which, when unmixed, perfectly resists the most violent fire without shewing any tendency to fusion, being mixed with equal parts of any calcareous or gypseous earth, and with two parts and a half, or three parts of any sand or vitrifiable stone, now becomes fusible, and disposes the other two earths to fusion.

All the properties which we have enumerated are essential to argillaceous earth, when perfectly pure; that is, when free from any mixture of heterogeneous matter. Clay so perfectly pure has never yet been found in the earth.

Mr. Macquer, in his Memoir upon clays given to the Academy in the year 1762, from which Memoir the greatest part of the present article is taken, observes, that clay being an earth miscible with water, is liable to mixture with many other matters, and that from this cause we never find pure clay, which ought eminently and exclusively to possess the argillaceous properties, and which ought to be always the same, without any peculiar differences; and lastly, that the only certain method of procuring this earth is to extract it from native clays, or from other bodies which contain it, by means of vitriolic acid, with which it forms alum, and then to decompose this alum by phlogiston or alkalis, which disengage the vitriolic acid; therefore, properly speaking, earth of alum well prepared can be considered as the only pure clay. Further, this earth has so strong affinity with phlogiston, that we cannot expect to obtain it perfectly free from this principle. The general properties of clay, described above, are then solely applicable to this kind of earth. *See the word* ALUM.

Native clays possess more or less of these properties in proportion as they are less or more altered by mixture of heterogeneous matters.

As clays are very useful in chemistry, in arts, and in many purposes of ordinary life, we shall mention some important parts of knowledge concerning them; as, the methods of discovering their purity, the places where they may be found, and the means of purifying them.

The purity of clays is known by the general properties above related. The more any native clay possesses of these properties, the purer it is.

The substances which hurt the purity of native clays are sand, phlogiston, bituminous matters, vitriolic acid, metallic earths, pyritous matters, calcareous earths, and mica.

Inflammable matters alter the color of clay, which when pure ought to be white. Its color is affected alſo by colored metallic earths, particularly by thoſe of copper and iron, and by all pyritous matters.

Clay, which is colored only by an inflammable matter which is not metallic, loſes its color by fire with acceſs of air, and becomes white. Of this kind are moſt grey and brown clays, of an uniform color, and not veined.

Clays colored by pyritous matters, or by earths of iron or copper, are not rendered white by fire, till they are perfectly deprived of theſe metallic earths. A certain quantity of theſe heterogeneous ſubſtances in clay render it fuſible. Such clays are known by their colors, which are yellow, red, green, or veined, and marbled with ſeveral of theſe colors. They are the moſt unfit of all clays for the making of utenſils intended to ſuſtain intenſe heat, ſuch as chemical veſſels, and the bricks, crucibles, or pots uſed in glaſs-houſes.

We may obſerve, that even the pureſt native clays are never entirely free from a mixture of ſome parts of metallic, particularly ferruginous earth. Mr. Macquer, who has examined above eight hundred clays, ſays, in the above quoted Memoir, that in all that number he did not find one, even amongſt the whiteſt, that was entirely pure and free from metallic matter: but when a very ſmall quantity only of ferruginous earth is in clays; when it is not uniformly mixed with them through all their maſs, which is known by a beautiful and pure white color, but is diſperſed in ſmall yellow ſpots, as it frequently is; then ſuch clays ought to be conſidered as being of a very good quality. The only practical method of ſeparating theſe ferruginous parts, is to break the clay into ſmall lumps, and to cut out the yellow ſpots. This ought to be done before the clay is mixed with water; becauſe by waſhing the ferruginous parts are not ſeparable, but are more intimately mixed with the purer part of the clay.

Pyritous matters, mica, and coarſe ſand mixed with clays render them brittle, and diminiſh their ductility. Clays are eaſily cleanſed from the greateſt part of theſe heterogeneous ſubſtances by waſhing; that is, by mixing the clay well with much pure water, which is left to reſt till only the fineſt and lighteſt parts of the clay remain ſuſpended in the water, the groſſer parts having ſubſided to the bottom: the water then is to be decanted off from the groſs ſediment, and paſſed through a fine ſilken ſearce: the ſediment which is depoſited from this decanted and ſifted water is the fineſt and pureſt part of the clay, and ought to be carefully and cleanly collected and dried. This purification of clay by waſhing is very neceſſary when good pottery or porcelain is to be made. *See* POTTERY *and* PORCELAIN.

The pyritous particles found in clays render them very fuſible. A bit of pyrites left in clay which is expoſed to a baking fire, always forms a cavity in the clay lined with a black leaden color.

The waſhing with water is an effectual method of ſeparating from clay even the ſmalleſt particles of pyrites; becauſe theſe particles have eſſentially a ſpecific gravity much greater than that of clay. But ſand and mica are not ſo eaſily ſeparated from clay. Mr. Macquer has ſhewn in his Memoir, that the moſt careful waſhing is inſufficient for an entire ſeparation of ſandy particles contained in clays; becauſe every native clay contains a conſiderable quantity of ſandy particles as fine and as light as the clay itſelf.

Mica

Mica alſo cannot be ſeparated from clay for the ſame reaſon: but theſe fine particles of ſand and mica, which cannot be ſeparated by waſhing, do not injure works made of the clay, but are rather uſeful by preventing cracks in drying and baking. *See* POTTERY.

The particles of calcareous earths which injure the purity of many native clays, are eaſily diſcovered by the efferveſcence which they make with nitrous acid. This kind of earth cannot be ſeparated from clays by waſhing, from the fineneſs and lightneſs of its parts. Clay containing a certain quantity of calcareous earth is by this mixture rendered fuſible, from the ſandy particles inſeparable from the clay: hence all calcareous clays are improper for making utenſils intended to ſuſtain intenſe heat.

Laſtly, vitriolic acid, which appears to have been combined and diſtributed in a ſingular manner by nature in all clays, may be ſeparated from them by digeſting them in an alkaline liquor, and afterwards by edulcorating this clay with a ſufficient quantity of water: but this purification of clays is not neceſſary for moſt purpoſes to which theſe earths may be applied; becauſe this acid is not injurious. Vitriolic acid mixed with clays renders them capable of decompoſing nitre and common ſalt, and of diſengaging the acids of thoſe ſalts.

Theſe extraneous matters being found naturally mixed with clays either ſingly, or ſeveral together, and in all proportions, occaſion a great variety of native clays. No earth has ſo many different kinds; and undoubtedly from this great variety proceeds the multiplicity of names which are annexed to the ſeveral kinds of clay.

The earths called *boles*, *bolar earths*, and *ſealed earths*, are true clays. Their names have been chiefly applied to thoſe clays which ſtick ſtrongly to the tongue, and alſo to certain clays filled with a large quantity of ferruginous earth, by which they are uniformly colored red or yellow. Other names are applied to clays from their particular uſes. Such are *fuller's-earth*, *tile-earth*, *brick-earth*, *potter's-clay*, *pipe-clay*, *porcelain-clay*.

The earths called *marles*, as they are capable of dilution in water, have a certain degree of binding quality, effervеſce with nitrous acid, are fuſible with an intenſe heat, and appear to be nothing elſe than clays more or leſs ſandy, and mixed with much calcareous earth.

Laſtly, epithets are given to many clays denoting their color, as *white clays*, *grey clays*, *blue clays*, *&c.*

But theſe names communicate little knowledge on the true nature of the ſeveral native clays. A more particular examination by chemical proofs is requiſite to inveſtigate the heterogeneous matters with which different native clays are mixed, the mixture of which alters the purity of ſimple and primary argillaceous earth, to which they owe all they poſſeſs of argillaceous properties; then names might be given which ſhould indicate their color and the heterogeneous matters with which they are mixed, or at leaſt thoſe which prevail moſt. Thus amongſt theſe names we ſhould have *white, ſandy, micaceous, or calcareous clays*; *grey* or *blue pyritous clays*; *red or yellow ferruginous clays*; *black bituminous clays*, &c.

As our intention in this work is not to enter into the details of natural hiſtory, we ſhall ſay no more upon this ſubject. What we have ſaid concerning the properties of pure clay, and the different ſubſtances which alter its purity, and more or leſs diſguiſe the argillaceous properties of native clays, is ſufficient to give a

notion of the light which chemistry can throw on natural history in this and many other instances.

In Mr. Gellert's table the substances capable of acting upon clays are set down in the following order: Vitriolic acid, partly (*see* an explanation of this word *partly* at the article ALUM), liver of sulphur, fixed alkali, borax, calx of lead, calx of antimony, gypseous earth, calcareous earth.

CLXX. CLOVES. (*m*)

CLXXI. CLYSSUS. By the word *clyssus* are meant the vapors which rise during the detonation of nitre with any inflammable body. These vapors may be collected and condensed into a liquor by a proper apparatus of vessels.

The vapors resulting from the detonation of nitre with charcoal are called *clyssus of nitre*. To prepare this clyssus, an earthen retort must be employed capable of sustaining a great heat applied suddenly without injury.

This retort, which ought to be tubulated, is to be placed in a furnace, and to it a very large balloon with a small hole is to be adjusted. When the bottom of the retort has become red-hot, a small quantity, that is, a dram and a half, or two drams, of a mixture of purified nitre and charcoal powder, is to be thrown into the retort through the tubulated part, which must be immediately afterwards closed; the nitre then detonates, and the vapors are condensed in the receiver.

Other parcels of the detonating mixture are to be thrown in successively with the same management, till a sufficient quantity of liquor is collected in the receiver. If, instead of charcoal-powder, sulphur be employed to detonate with nitre in close vessels, the liquor obtained is called *clyssus of sulphur*; and if antimony be employed to detonate with nitre, the liquor is called *clyssus of antimony*.

The old chemists who have practised these operations believed, that the liquors thus obtained had particular virtues for alchemical purposes. For this reason, they made this preparation with great apparatus and trouble. But now, when chemical operations are better understood, these liquors are believed to have no virtues. The clyssus of nitre is made in laboratories, not for any use to which it can be applied, but to establish a theory concerning the nature of nitrous acid, and to prove that this acid is entirely destroyed and decomposed by detonation.

For, when the operation is finished, nothing is found in the retort but the alkali which was the basis of the nitre; and the liquor contained in the receiver has no acid taste, does not redden the tincture of turnsol, makes no effervescence with alkaline matters, and is truly nothing but water, which is sometimes slightly

(*m*) CLOVES. The pungency of cloves resides in their resin, or rather in a combination of resin with essential oil; for the spirituous extract is very pungent; but if the oil and the resin contained in this extract be separated from each other by distillation, the oil will be very mild; and any pungency which it does retain proceeds from some small portion of adhering resin, and the remaining resin will be insipid. No plant, or part of any plant, contains so large a proportion of essential oil as cloves do. From sixteen ounces Neuman obtained by distillation two ounces and two drams, and Hoffman obtained from the same quantity an ounce and a half. This oil is specifically heavier than water. *Neuman.*

alkaline,

alkaline, becauſe the force of detonation is capable of raiſing ſome ſmall part of the alkali of the nitre.

The clyſſus of ſulphur is acid, becauſe the vitriolic acid of the ſulphur is not decompoſed, as the nitrous is, by combuſtion, but is diſengaged and ſet at liberty by the burning of the phlogiſton of the ſulphur. Beſides, one part of this vitriolic acid when diſengaged acts upon the nitre, forms with its baſis a vitriolated tartar called *Glaſer's ſal polychreſtum*, and diſengages the nitrous acid. This portion of nitrous acid thus diſengaged by the acid of ſulphur, and which is no longer retained and fixed by an alkali, is not capable of inflaming with phlogiſton: wherefore it is not decompoſed, and, together with the vitriolic acid which is not fixed by the alkali of the nitre, makes part of the clyſſus.

The clyſſus of ſulphur appears then to be compoſed, 1. Of a part of the nitrous acid deſtroyed by inflammation with the phlogiſton of the ſulphur: 2. Of another portion of nitrous acid which is not decompoſed, but is diſengaged by the acid of ſulphur: 3. Of all the acid of ſulphur which does not unite with the alkaline baſis of the nitre.

The clyſſus of ſulphur muſt differ conſiderably according to the proportions of nitre and of ſulphur employed. If a little nitre be added to much ſulphur, the clyſſus will be almoſt all pure acid of ſulphur.

An Engliſh chemiſt *, ſome time ago, found a method of obtaining very advantageouſly the vitriolic acid of ſulphur, by burning ſulphur in cloſe veſſels with a ſmall quantity of nitre. This method of decompoſing ſulphur for the extraction of its acid is ſaid to be executed in great, and to be the cauſe of the great reduction of the price of that acid within theſe few years paſt. This is an inſtance of practical utility from a clyſſus; for the vitriolic acid obtained by detonation of nitre in cloſe veſſels is a true clyſſus of ſulphur.

The clyſſus of antimony is ſimilar to that of ſulphur; for the nitre in this operation chiefly detonates with the ſulphur of the antimony: however, the phlogiſton of the metalline part of the antimony contributes alſo to the detonation. Beſides, ſome flowers of antimony are mixed with this clyſſus.

Several neceſſary precautions ought to be taken to make this operation of a clyſſus ſucceed, and to avoid accidents; for the rapidity and violence with which nitre detonates in certain circumſtances may occaſion a ſtrong exploſion and rupture of the veſſels. To prevent theſe accidents, the inflammable matters ought not to be very well mixed with the nitre, becauſe the detonation is proportionably ſtronger and quicker as the mixture has been made more exactly. Alſo, a ſmall quantity only of the mixture ought to be detonated at once, and another quantity ſhould not be added till the detonation of the former be finiſhed. *See* NITRE, DETONATION *of* NITRE, and GUN-POWDER.

CLXXII. COAGULATION. This term is employed by chemiſts to denote certain operations in which fluid bodies become ſolid; for inſtance, the cryſtallization of ſalts. *See* CRYSTALLIZATION.

CLXXIII. COAGULUM. This Latin word is uſed to ſignify curdled concretions formed by the mixture of two liquors, ſuch as the precipitate of ſilver in the formation of *luna cornea*, the *offa Helmontii*, the *miraculum chemicum*, and many others. *See theſe words.*

* Dr. Ward. *See* SPIRIT *of* SULPHUR.

CLXXIV. COAL. By the word *coal* is meant any ſubſtance containing oil which has been expoſed to fire in cloſe veſſels, ſo that all its volatile principles are expelled, and that it can ſuſtain a red heat without further decompoſition. Coal is a body ſolid, black, very dry, and conſiderably hard.

The ſpecific character of perfect coal is its capacity of burning with acceſs of air, while it becomes red-hot and ſparkles. ſometimes with a ſenſible flame which gives little light, no ſmoke or ſoot capable of blackening white bodies.

Coal is capable of communicating its inflammable principle either to the vitriolic acid, with which it forms ſulphur; or to the nitrous acid contained in nitre, with which it inflames; or to metallic earths, which it reduces into metals. But the phlogiſton cannot paſs from coal to form theſe new combinations without the aſſiſtance of red-heat.

Coal ſeems to be an unalterable compound in every inſtance but theſe mentioned, of burning in open air, and of communicating its phlogiſton to other bodies: for it may be expoſed in cloſe veſſels to the moſt violent and continued fire without ſuffering the leaſt alteration. No diſpoſition to fuſe, nor any diminution of weight can be perceived. It is a ſubſtance exceedingly fixed, and perhaps the moſt refractory which is known.

No change is produced upon coal by air or by water, nor by the moſt powerful menſtruums of chemiſtry, excepting perhaps by particular proceſſes. A trial might be made whether the concentrated mineral acids, or cauſtic alkalis, would not, when aſſiſted by heat, make ſome alteration upon coal in a long time. The younger Mr. Rouelle propoſed as a problem, in the Journal de Medicine for October, 1762, to *diſſolve vegetable coal in the palm of the hand.* Why he propoſed it as a problem we do not know; ſince he adds, that Mr. Wolf has reſolved it, and that this ſolution may be made by liver of ſulphur. He has not explained whether he means the ſolution of all the ſubſtance of the coal, or of its phlogiſton only.

Coal is evidently a reſult of the decompoſition of the compound bodies from which it is obtained. It conſiſts of the greateſt part of the earthy principle of theſe compound bodies, with which a part of the ſaline principles, and ſome of the phlogiſton of the decompoſed oil are fixed and combined very intimately.

Coal can never be formed but by the phlogiſton of a body which has been in an oily ſtate: hence it cannot be formed by ſulphur, phoſphorus, metals, nor by any other ſubſtance the phlogiſton of which is not in an oily ſtate.

Alſo every oily matter treated with fire in cloſe veſſels furniſhes true coal; ſo that whenever a charry reſiduum is left, we may be certain that the ſubſtance employed in the operation contained oil. *See* OIL.

Laſtly, the inflammable principle of coal, although it proceeds from an oil, is certainly not an oil, but is pure phlogiſton; ſince coal added to vitriolic acid can form ſulphur, to phoſphoric acid can form phoſphorus, to metallic earths can form metals, and can detonate with nitre; and ſince oil can produce none of theſe effects, till it has been decompoſed and reduced to the ſtate of coal. *See* SULPHUR, PHOSPHORUS, METALS, NITRE, *and* OIL.

Beſides, the phenomena accompanying the burning of coal are different from thoſe which happen when oily ſubſtances are burnt. The flame of charcoal is not ſo bright as that of oil, and produces no ſmoke or ſoot.

All the phlogiston of coal is not burnt in open air, particularly when the combustion is slow. One part of it exhales without decomposition, and forms a vapor, or an invisible and insensible gas. This vapor, or this phlogiston, disengaged from coal, is very pernicious. It so affects the brain and nerves as to occasion instant death. For this reason, to remain in a close place where charcoal or other coal is burnt, is dangerous. Persons struck by vapor of charcoal are stunned, faint, suffer a violent head-ach, and fall down senseless and motionless. If they are yet alive, the best method of recovering them is to expose them as quickly as is possible to open air, and to make them swallow vinegar, and breathe its steam. Acids, and particularly vinegar, seem to have a property of fixing and restraining in some sort the action of phlogiston, and of the vapors of volatile inflammable matters, which produce similar effects on animals. For this reason, vinegar diminishes the accidents of intoxication occasioned by spirituous liquors and by opium. The vapor which exhales from liver of sulphur, particularly when a large quantity of it is decompesed by an acid, and the vapors which exhale from matters undergoing the spirituous or putrid fermentation, produce the same accidents as the vapors of coal, and are remedied by the same means.

Amongst coals, some differences are observable, which proceed from the difference of the bodies from which they are made; particularly, some coals are more combustible than others. This combustibility of coals seems to depend on the greater or less quantity of saline principle contained in coal; that is to say, that the more it contains of saline principle, the more easily it decomposes and burns. For example, coals made of plants and wood, containing much saline matter capable of fixing it, the ashes of which contain much alkaline salt, burn vigorously and produce much heat; whereas the coals of animal matters, the saline principles of which are volatile, and cannot be fixed but in small quantity, and the ashes of which contain little or no alkaline salt, are scarcely at all combustible. For they not only do not kindle so easily as charcoal does, nor ever burn alone, but they cannot be reduced to ashes without very great trouble, even when the most effectual methods are used to facilitate the combustion.

I have kept the coal of bullock's blood very red-hot in a shallow crucible, surrounded with burning charcoal, six hours and more, and stirred it constantly that it might all be exposed to the air, but I could not reduce it to white or even grey ashes. It remained still very black, and full of phlogiston.

The coals of pure oils, or of concrete oily substances, and soot, which is a kind of coal raised during the inflammation of oils, are as difficultly burnt as animal coals. These coals contain very little saline matter, and their ashes furnish no alkali.

These coals, which are so difficultly burnt, are also less capable of inflaming with nitre than others more combustible; and some of them even in a great measure resist the action of nitre.

The refractory quality of coals is a singular property. This property is in so great a degree, that they are found to be the fittest substances for supporting bodies exposed to the focus of large burning-glasses. Nevertheless all coal is composed of an earth which is not perfectly refractory, of a saline matter which is fusible and assists the fusion of other substances, and of phlogiston which is

certainly the principle of the fusibility of metals, as their earths become so much more difficult to fuse as they are more dephlogisticated. (*n*)

CLXXV. COAL (FOSSIL). (*o*)

CLXXVI. COATING. (*p*)

CLXXVII. COBALT. This name is given by authors to several different minerals. We shall here only talk of that kind of cobalt which contains the metallic matter whose calx furnishes a blue glass when vitrified; because the name *cobalt* ought to be confined to this mineral alone, to avoid the uncertainty and confusion too frequent in names of natural history and of chemistry.

Cobalt is a very heavy mineral, of no determinate figure; of a grey color, more or less brilliant; of a fine, compact, close grain, the surface of which,

(*n*) To *make charcoal*, or vegetable coal, pieces of wood are so disposed as to form a pile, generally conical, which pile is covered with turf to prevent the too free draught of air, by which the wood would be reduced to ashes and not to coal. The pile is then to be kindled, and the fire is to be continued till all the watery and the more volatile parts of the wood are dissipated; that is, till no more smoke arises, at which time the wood is thoroughly red-hot. The external air is then to be totally excluded, by covering the pile with earth, and thus the fire is extinguished.

(*o*) COAL (FOSSIL), or PIT-COAL, is a black or brown, laminated, bituminous substance, not very easily inflammable, but which once inflamed, burns longer and more intensely than any other substance. Of this substance three kinds are distinguished by authors. The residuum of the first after combustion is black; the residuum of the second is spongy, and like pounce stone; and the residuum of the third is whitish ashes. Some fossil coal, by long exposure to air, falls into a greyish powder, from which alum may be extracted. Fossil coal by distillation yields, 1. a phlegm or water; 2. a very acid liquor; 3. a thin oil like naphtha; 4. a thicker oil, resembling petroleum, which falls to the bottom of the former, and which rises with a violent fire; 5. an acid concrete salt; 6. an uninflammable earth remains in the retort. These constituent parts of fossil coal are very similar to those of amber and other bitumens. *See* BITUMEN. For the exciting of intense heats, as of furnaces for smelting iron-ore, and for operations where the acid and oily vapors would be detrimental, as the drying of malt, fossil coals are previously charred, or reduced to *coaks*; that is, they are made to undergo an operation similar to that by which charcoal is made. By this operation coals are deprived of their phlegm, their acid liquor, and of greatest part of their fluid oil. Coaks therefore consist of the two most fixed constituent parts, the heavy oil and the earth, together with the acid concrete salt, which though volatile is detained by the oil and earth.

(*p*) COATING, or LORICATION, is an application of clay, or mixture of clay with sand or other substance, to the external or internal surfaces of chemical vessels, to guard them against the effects of sudden heat, or of the corrosive quality of the matter to be contained. Thus glass retorts intended to be exposed to what is called a naked fire, that is, to a fire without interposition of a sand-bath or other substance, ought to be externally coated, by which means they will not be so liable to be cracked by the sudden application of heat and cold. Retorts may be coated in the following manner: Take of clay and sand equal parts; make them into a thin paste, with fresh blood prevented from coagulating by agitation till it be cold, and diluted with water; add to this paste some hair and powdered glass; with a brush dipt in this mass besmear the retort; and when this first layer is dry, let the same operation be repeated twice or oftener, till the coat applied be about one-third part of an inch thick. For the compositions for coating crucibles, furnaces, and other instruments made of plate-iron, *see* CRUCIBLE.

when it has been exposed to the air, is covered with a powder, or efflorescence of the color of a peach-blossom.

This mineral is not found in many places. Hitherto it seems to have been found only in Saxony and in the Pyrenean mountains (q). It contains several substances mixed and confounded together, and in this respect some cobalts differ from others. All of them contain sulphur, much arsenic, and the semi-metal the calx of which may be made into blue glass, and which Mr. Brandt of the Swedish Academy calls *Regulus of Cobalt* when it is reduced to its metalline state. Besides these substances, some cobalts contain bismuth, silver, or both of these.

Of all these matters, the peculiar regulus of cobalt renders this mineral valuable from the fine blue which is manufactured from it, and which is the only blue that can be used in vitrification.

Nevertheless other substances are collected from cobalt in the operations practised on it, but only secondarily, because these substances may be obtained without additional labor or expence. For example, as it is necessary in the preparation of the blue to expel the arsenic, this mineral must be exposed to long roastings; instead of dissipating the arsenic which rises in vapors during the torrefaction, it is collected in long crooked chimneys, adapted to the furnaces in which the cobalt is roasted, and thus is obtained almost all the arsenic which is sold in commerce. *See* ARSENIC.

Likewise after the roasting, when the calx of cobalt is fused with vitrifiable matters to make the blue glass called *Smalt*, the bismuth and silver may be separated and collected.

(q) Cobalt has been found in Cornwall, Scotland, and probably in other parts of Europe. That it is in the eastern parts of Asia, appears from the blue coloring on old oriental porcelain. Probably also the mines discovered in these countries are nearly exhausted, as considerable quantities of zaffre and smalt are exported from Europe to China. Besides the grey or ash-colored cobalt described in the text, which is the most frequent, other cobalts are found of various colors and textures, mixed with various substances. Wallerius enumerates six species of cobalts. 1. The *ash-colored ore*, which is regulus of cobalt mineralised by arsenic, consisting of shining leaden-colored grains. Some ores of this kind are compact, resembling steel, and others are of a loose texture and friable. 2. The *specular ore* is black, shining like a mirror and laminated. This species is very rare, and is supposed by Wallerius to be a foliated spar, or selenites mixed with ore of cobalt. 3. The *vitreous*, or *slag-like ore*, is of a blueish, shining color, compact, or spongy. 4. *Crystallized ore of cobalt* is a grey, deep-colored ore of cobalt, consisting of clusters of cubical, pyramidal, prismatic crystals. 5. *Flowers of cobalt*, red, yellow, or violet. These flowers seem to be formed from some of the above described compact ores, decomposed by exposure to moist air. This decomposition is similar to that which happens to ferruginous and cupreous pyrites. 6. The *earthy ore of cobalt* is of a greenish white or of a yellow color, and of a soft and friable texture. This species seems to be an ochre of cobalt, and is formed perhaps from the flowers of cobalt further decomposed, in the same manner as a martial ochre is formed from the saline efflorescence of decomposing pyrites, when this efflorescence is further decomposed by exposure to moist air; by which the vitriolic acid contained in it is expelled, and the efflorescence is changed from a saline state to that of an ochre or calx. Besides these proper ores of cobalt, it is also found in a blue clay along with native silver, in ores of bismuth, and in the mineral called kupfer-nickel. *See* NICKEL.

The [illegible] although [illegible] valuable metal, is generally in so small a quantity, [illegible] be not be worth the trouble of obtaining on purpose from this mineral. The cobalt is therefore always operated upon for the sake of the blue.

If well-calcined cobalt be treated with phlogiston and fluxes, like other metallic calxes, it will be reduced to a semi-metal, called, by Mr. Brandt, who first discovered it, the *Regulus of Cobalt*.

This regulus, and also the calx of cobalt, amongst other singular properties, has that of making a very curious sympathetic ink, by being dissolved in aqua regia. *See, for what further relates to cobalt, the articles* SMALT, ZAFFRE, AZUR, REGULUS *of* COBALT, *and* INK (SYMPATHETIC).

CLXXVIII. COCHINEAL. *(r)*

CLXXIX. COERULEUM MONTANUM. *(s)*

CLXXX. COHESION. By cohesion is meant the adhesion which the integrant or the constituent parts of bodies have to each other.

CLXXXI. COHOBATION. Cohobation is an operation by which the same liquor is frequently distilled from the same body, either with an intention to dissolve this body, or to produce some change upon it. This is one of those operations which the ancient chemists practised with great patience and zeal, and which are now neglected.

To make this operation easier, and to prevent the trouble of frequently changing or moving the vessels employed, a particular kind of alembic is contrived, very convenient and well adapted, called a *Pelican*. *See* PELICAN.

CLXXXII. COLCOTHAR. Colcothar is the substance which remains from the calcination and distillation of martial vitriol with a violent fire.

Vitriolic acid does not adhere so strongly to the iron of the martial vitriol as to be capable of resisting the action of a strong fire; therefore when this vitriol is heated intensely and during a long time, it loses more and more of its acid, which is dissipated if the calcination be performed in open vessels, and which may be distilled with proper apparatus. When the vitriol loses its

(r) COCHINEAL. From an ounce of cochineal Neuman obtained by distillation two scruples of phlegm, four scruples of urinous spirit, fifteen drops of oily spirit, twenty-two grains of volatile alkali, five scruples and two grains of empyreumatic oil, and two drams and two scruples of a residuum containing five grains of fixt lixivial salt. The same author found that of four drams of cochineal, three drams were soluble in water, and nearly as much in spirit of wine.

Cochineal infused or boiled with water produces a crimson tincture inclining to purple. Fixed alkali renders the crimson deeper, but lessens its lustre. Volatile alkali heightens the color without diminution of lustre. The best method of applying volatile alkali for this purpose in dying was found by Mr. Hellot to be, by dipping the cloth dyed with cochineal in a solution of sal-ammoniac, and then throwing into the solution some pot-ash, by which the volatile alkali of the sal-ammoniac is disengaged. By a small quantity of vitriolic acid the crimson decoction of cochineal is rendered purple, by more of that acid it is rendered flesh-colored, and by still more colorless. This color is first changed to a yellow, and afterwards destroyed by nitrous acid. Solution of tin in aqua regia heightens the color of this decoction to a scarlet. French dyers give a scarlet tinge to this decoction by turmeric; but this tinge does not penetrate the cloth, and is not durable. *See* DYING.

(s) COERULEUM MONTANUM, *mountain-blue*, called by some authors *chrysocolla*, is a blue ore of copper. *See* ORES *of* COPPER.

acid,

acid, it acquires a red color, and becomes an earthy matter. The calx of iron, whether it has been deprived of phlogiston by fire or by acids, is always of this red color: but the iron contained in vitriol suffers this alteration during the calcination. When the calcination is finished, what remains of the vitriol has still some taste, and even the property of becoming moist when exposed to air. These qualities are caused by some remaining acid which adheres obstinately to the earth of the iron, and which the fire could not expel. As this acid is very much concentrated, and is not combined with the calx of iron in the colcothar, as it was with the iron itself in the vitriol, because the phlogiston of the iron is lost by calcination, we need not wonder that this calcined vitriol should powerfully imbibe moisture from the air, although vitriolic does not.

This remaining acid may be taken from the colcothar by washing with water. The colcothar then has no taste, does not attract moisture from the air, and is called *Sweet Earth of Vitriol.*

Unwashed colcothar is used in medicine, but only externally. It may be properly applied to all putrid, sanious and fungous ulcers, because it is antiseptic, strongly tonic, astringent, and even corrosive, from its remaining uncombined vitriolic acid. *See* VITRIOL (MARTIAL) *and* CALCINATION.

CLXXXIII. COLOPHONY. Colophony, or rosin, is the resinous residuum after the distillation of the light oil from turpentine. It has also the properties of other resins, and the same principles may be obtained from it by analysis. *See* BALSAMS (NATIVE); TURPENTINE; *and* RESIN.

CLXXXIV. COLOCYNTH. *(t)*

CLXXXV. COLORS. *(u)*

CLXXXVI. COMBINATION. By the word *combination*, we ought to understand the union of two bodies of different natures, from which a new compound body results. For example, when an acid is united with an alkali, we say that a combination betwixt these two saline substances takes place, because from this union a neutral salt results which is composed of an acid and an alkali. *See* COMPOSITION.

CLXXXVII. COMBUSTION. Combustion is nothing else than the disengagement of the inflammable principle contained in several kinds of bodies, which are therefore called *combustible.*

The principle of inflammability is united in greater or less quantity with bodies, and in several different manners; hence the diversity occasioned in the phenomena of combustion.

If the phlogiston of a body be in large quantity, and in an oily state, this body is very combustible, and burns with a bright flame, accompanied with smoke and soot. Wood, dry vegetables, resins, oils, fat, are combustible bodies of this kind.

If the phlogiston of a body be not in an oily state, but in large quantity, or not very intimately combined, this body may also be very combustible, and may

(t) COLOCYNTH, or COLOQUINTIDA, is a bitter fruit, from an ounce of which Neuman extracted by spirit three ounces and a half, and by water seven ounces and a half.

(u) Colors. See BLACK, BLUE, &c. *and* DYING.

even burn with flame. But this flame is lighter and generally less luminous than the flame of oily bodies; besides, it is accompanied with no smoke or soot. Spirit of wine, sulphur, phosphorus, charcoal, some metallic matters, and particularly zinc, are combustible bodies of this kind. The flames of phosphorus and of zinc are nevertheless very luminous.

Lastly, bodies containing phlogiston which is not in an oily state, and which is in small quantity, or strongly combined with other uncombustible principles, burn difficultly without any sensible flame; such are certain animal coals, soot, ashes of vegetables containing very little phlogiston, and imperfect metals.

The grand principle concerning combustion in general is, that no combustible matter can burn without access of air, and that the more immediate its contact with air is, the more rapid and compleat is its combustion. *See* Air.

For this reason, even the most inflammable bodies, as spirit of wine and ethereal oils, do not burn but at their surface, because that only is exposed to air. For the same reason, inflammable bodies, when reduced to vapor, burn rapidly and instantaneously, because they are all exposed to air at once. Lastly, for the same reason, some bodies, though full of phlogiston, such as fat, oils, &c. cannot burn without a heat sufficient to reduce them into vapor.

The practical methods of promoting, accelerating, and of compleating the combustion of the inflammable principle of bodies may also be naturally deduced from what we have said on this subject. These methods consist in applying as much of these bodies as possible to the air. Thus by directing a current of air upon the burning bodies, their combustion is accelerated and augmented in proportion as this current is stronger, as the effects of bellows and air-furnaces evidently prove.

Most oily bodies, as wood, burn with much flame, which lasts while any sensible quantity of oil remains: after which the flame ceases. They are not however yet deprived of all their inflammable principle, a part of which remains in the state of coal. Then the remaining part of the body may continue to burn, if it contains much phlogiston, but without a luminous flame, and in the manner of charcoal.

In proportion as the phlogiston is consumed by this second combustion, what remains of it becomes more and more difficultly combustible; not only because the least fixed and adherent part of it is first burnt, but also because the proportion of incombustible matter, to which this phlogiston is united, becomes greater and greater. Hence when this combustion has arrived at a certain point, that is, when a small portion of phlogiston only remains strongly combined, and also covered and defended by a large quantity of incombustible matter, this remaining phlogiston will not burn alone, and is nearly in the same state as that of most metallic matters. If, therefore, this combustion is to be compleated, which then is called *calcination*, fire must be applied from some other fuel, with which the body to be calcined or dephlogisticated is to be penetrated, and kept red-hot; and as much air is at the same time to be applied to the body, till no longer any marks appear of its inflammable principle. Ashes of vegetables, soot, coals of oils and of animal matters, and several metallic substances, contain some phlogiston in this last state.

When the phlogiston of these substances is to be entirely burnt or dissipated, all the means capable of favoring combustion ought to be made to concur.

The

The ſubſtances ought to be firſt divided into very ſmall parts, becauſe then they preſent more ſurface to the air than when in one maſs. They are then to be expoſed to the action of fire in a convenient veſſel, ſo that the air may have free acceſs; as for example, in a wide-mouthed teſt, and under a muffle open on the ſide at which air is introduced into the furnace. To accelerate further this operation, a current of air may be directed upon the ſurface of theſe bodies, and they may be frequently ſtirred, that all their parts may be ſucceſſively preſented to air. The ſtrongeſt fire which the matter can ſuſtain without fuſion ought to be applied; becauſe a melted body forms always one maſs, and preſents leſs ſurface than when it is divided in ſmall detached parts. Thus fuſible bodies, as aſhes, alkaline ſalts and metals, ought to be calcined with a moderate heat, and proportioned to their fuſibility.

The laſt portions of the phlogiſton of certain bodies are ſo difficultly combuſtible, that notwithſtanding all theſe means united, they never can be entirely burnt.

Some of them even, as the perfect metals, are conſidered as bodies entirely incombuſtible, becauſe they can ſuſtain the moſt violent fire during entire months, without ſuffering any ſenſible alteration. Nevertheleſs, Junker affirms, that gold and ſilver may be calcined, if they are treated during ſix months, by reverberation, in the manner of Iſaacus Hollandus.

Although the certainty of this experiment has not been ſufficiently confirmed by repeated trials, the method of calcining theſe metals propoſed by this chemiſt agrees ſo well with the great principles of combuſtion, that its ſucceſs ſeems very probable. *See* CALCINATION.

CLXXXVIII. COMPOSITION *of* BODIES. Chemical compoſition is the union and combination of ſeveral ſubſtances of different natures, from which a compound body reſults. From this union of bodies of different nature a body is formed of a mixed nature, which Becker and Stahl have called a *mixture*, and which may be called a *combination* or *chemical compoſition*, to avoid the equivocal ſenſe of the word *mixture*, by which may be underſtood only a mere interpoſition of parts, and which therefore would give a very falſe idea of chemical compoſition, in which a mutual adheſion takes place between the combined ſubſtances.

When the ſubſtances conſidered by chemiſts as *ſimple*, or *primary principles*, are combined together, they form the firſt compounds, to which Becker and Stahl give, by way of excellence, the name *Mixts*. The ſame chemiſts call the bodies formed from the union of theſe mixts, *compounds*. When they treat of more complicated combinations, they talk of *decompounds* and *ſurdecompounds*.

This diſtribution of bodies, more or leſs compounded, is juſt and conformable to experience. But the names given by Becker and Stahl are not ſufficiently clear and accurate.

A more ſimple and clear method of diſtinguiſhing theſe ſeveral claſſes of bodies ſeems to be by numbers indicating their degree of compoſition. Thus we might ſay, compounds of the firſt, of the ſecond, of the third degree, &c. as Mr. Macquer propoſes in his courſe of chemiſtry.

CLXXXIX. CONCENTRATION. The concentration of a body conſiſts in approximating its proper and integrant parts, by taking away

ſome ſubſtance interpoſed betwixt theſe parts, and which is extraneous or ſuperabundant to the body to be concentrated. Thus, for inſtance, a ſolution of any ſaline ſubſtance in water may be concentrated by expelling part of the water of this ſolution. But cuſtom has applied the word concentration to the dephlegmation of acids, and particularly of vitriolic acid by diſtillation, and of vinegar by congelation. We proceed to both theſe concentrations.

CXC. CONCENTRATION *of* VITRIOLIC ACID. Vitriolic acid, procured either from vitriol or from ſulphur, is never ſufficiently pure for chemical operations. It always contains ſome extraneous ſubſtances from which it muſt be purified.

The heterogeneous matters which chiefly affect the purity of vitriolic acid, are ſuperabundant water by which it is weakened, and inflammable matter by which it is rendered black and ſulphureous. Theſe two ſubſtances are ſeparable by one and the ſame diſtillation, which is called the *concentration*, or the *rectification of vitriolic acid*. This acid ought to be diſtilled, whether it be both watery and ſulphureous, or have only one of theſe faults.

To explain what paſſes in this operation, and the management which muſt be obſerved, we will firſt conſider what happens in the concentration of vitriolic acid, which is only diluted with ſuperabundant water, and not phlogiſticated. We will then proceed to the changes produced upon this acid by diſtillation, when it is ſufficiently free from water, and is only phlogiſticated.

When vitriolic acid, diluted with ſuperabundant water, is to be concentrated, if it contains a conſiderable quantity of water, it may be diſengaged from the greateſt part of this ſuperfluous water in ſtone or glaſs bottles, without the apparatus of diſtillation. The greater the quantity of water which is united with the vitriolic acid, the leſs ſtrongly does a part of it adhere. As this water is much more volatile than vitriolic acid, it evaporates by almoſt the ſame degree of heat which is requiſite to the evaporation of pure water. While the water exhales, the parts of the vitriolic acid remaining in the veſſel are approximated, and the acid becomes more and more concentrated and ſtrong. Thus the operation proceeds very well to a certain point, and even better than by diſtillation. But when the acid has arrived at a certain degree of concentration, it cannot be compleated in open veſſels; becauſe the ſmaller which the quantity is of water united to the acid, the more ſtrongly it adheres; ſo that it cannot be ſeparated without a heat ſufficient to raiſe the acid alſo, which therefore in open veſſels would be loſt. But alſo another and more remarkable inconvenience occurs, which is, that when vitriolic acid begins to be much dephlegmated and very ſtrong, it becomes ſo greedy of moiſture that it attracts that of the ſurrounding air, as Mr. Beaumé has well obſerved, and perpetually combines with it; ſo that every inſtant it reſumes as much water from the air as it loſes by evaporation. The concentration of this acid muſt therefore be compleated in cloſe veſſels by diſtillation.

For this diſtillation, a retort of good glaſs, capable of reſiſting acids, muſt be filled half full with the vitriolic acid to be concentrated, and ſet in a ſand-bath covered entirely with ſand. After a receiver has been adapted to it, heat muſt be applied, and very gradually augmented till drops are diſtilled.

If the vitriolic acid contains little water, the diſtillation does not begin but with a conſiderable degree of heat, and the drops which fall into the receiver

are

are very acid. These drops fall very slowly, and the distillation must not be too much hastened. As the concentration advances, the drops follow each other at longer intervals, although the acid contained in the retort acquires more and more heat. Towards the end of the operation, and when the acid is much concentrated, care must be taken not to encrease the heat so much as to make the acid boil, which cannot be effected with less than a red heat. By this heat all the acid may be raised at once, in drops and burning vapors, which pass precipitately, and generally burst the retort.

When this accident happens, whether it proceeds from hastening the distillation too much, or from cold air striking the retort, the concentrated and burning acid is almost entirely reduced to white, thick, suffocating vapors which instantly fill the laboratory. The operators ought to remove themselves from such hurtful vapors.

The duration of this operation, and the quantity of phlegmatic acid to be distilled, so that the vitriolic acid shall be left highly concentrated, are absolutely indeterminate, as they depend on the degree of strength which this acid had before its concentration. The vitriolic acid, which was formerly kept by druggists, required that one half of it should be drawn off by distillation to make the remaining part twice as heavy as water. At present, it is much stronger, although cheaper. Some may be got very concentrated, and which only requires to be dephlogisticated in the following manner.

The vitriolic acid manufactured in the great, and sold in commerce, is always mixed with more or less inflammable matter, by which it is rendered black and opake. It may be entirely disengaged from this extraneous matter by a distillation similar to that above described.

The first portions of such an acid which passes in distillation are a very penetrating, volatile, sulphureous acid. If the phlogisticated vitriolic acid which is rectified be also phlegmatic, the distillation may be so managed that the liquor shall slightly boil. This liquor continues black till it is concentrated to a certain degree; when by help of a strong heat which it then acquires, the concentrated acid acts upon the inflammable matter, dissipates it, or completely burns it. The liquor in the retort becomes gradually clearer, and at length perfectly white and transparent. If this acid has also the requisite degree of concentration, the operation is finished when it thus becomes perfectly white and transparent. The retort must be left in the sand-bath till it is cold, and then the acid is to be poured into a clean, dry, crystal-glass bottle; considering that the smallest piece of inflammable matter is capable of phlogisticating and blackening rectified vitriolic acid; and that any moisture, besides weakening the acid, might occasion such heat as to break the bottle. When the acid is poured into the bottle, the neck of this bottle ought to be wiped dry, and closed by a glass stopper, accurately fitted and well wiped. The mouth of the bottle ought also to be guarded from dust by being covered with leather.

The phlegmatic or sulphureous liquor, which passed over into the receiver, is called *Spirit of Vitriol*. It is clear and white, and may be used in many operations where concentrated vitriolic acid is not requisite, or it may be concentrated and rectified.

CXCI. CONCENTRATION *of* VINEGAR *by* CONGELATION. Vinegar produced by the acetous fermentation is a vegetable

acid much used in chemistry. As this acid is mixed with much extractive matter and superabundant water, chemists have endeavored to render it more pure and strong.

It may easily be disengaged by a single distillation from almost all its extractive matter; *see* VINEGAR (DISTILLED); but it cannot so easily be deprived of its superabundant water. If vinegar be distilled with intention to concentrate it, as vitriolic acid is, the most watery and least acid part would always rise first; but the operation would succeed very imperfectly, because this acid is almost as volatile as water. To procure the concentration of vinegar, other expedients must be used. Chemists have discovered several which succeed well. For instance, by combining this acid with fixed matters, such as fixed alkalis and metals, and afterwards subjecting to distillation the salts resulting from such combinations, a very concentrated acid of vinegar is obtained, called, *Radical Vinegar*. *See upon this subject* TERRA FOLIATA TARTARI, SALT *of* LEAD, CRYSTALS *of* VERDIGREASE, and VINEGAR (RADICAL). We proceed here to describe another method of concentrating vinegar, by which indeed it cannot be so much dephlegmated as by the preceding methods, but it is much more simple, and has some peculiar advantages. The method is effected by congelation, or freezing.

Stahl seems to be the first who employed this method. Since which time Mr. Geoffroy has made many experiments on this subject, a relation of which is to be found in the Memoirs of the Academy for the year 1739.

As acids resist congelation much more than water, if vinegar be exposed to a cold sufficient to sink the mercury of Mr. Reaumur's thermometer eight or ten degrees below the figure 0, a considerable quantity of ice will be formed. This ice, being separated from the rest of the unfrozen liquor, consists of scarcely any thing but pure water, and the unfrozen liquor is a much stronger vinegar. By exposing again this vinegar to another and stronger frost, more ice is formed in it, less hard than the first ice, and somewhat resembling snow, because it contains a certain quantity of unfrozen acid; and may therefore be set aside for the extraction of this acid. The acid remaining after the second congelation is greatly stronger. This concentration of vinegar may be much encreased by repeating the congelation with greater cold Mr. Geoffroy relates in the quoted memoir, that vinegar which has been already concentrated by frosts of preceding years, and eight pints of which had been reduced to two pints and a half by the frost of January 29, 1739, was at length so much concentrated, that two drams of this vinegar, the saturation of which before these concentrations would have required six grains of salt of tartar, did now require forty-four grains for that purpose.

Stahl assures us, that wine may be well concentrated by the same method. He says, that he exposed to frost different kinds of wine, and that he had procured by this means two thirds, or three quarters of pure phlegm.

Wines thus concentrated had a thick consistence, were very strong, and were preserved without change many years, in places, where the free access of air alternately hot and cold, according to the seasons, would have soured or spoiled any other wine in a few weeks. The general opinion that wines are spoiled and entirely weakened by frost proceeds undoubtedly from the ice not being

taken off, but left to mix again with the wine when it thaws. Perhaps also some delicate wines are considerably altered by frost.

Wallerius says, that in the northern countries cold is successfully used to concentrate sea-water, and to approximate the particles of salt, by separating the ice as soon as it is formed, and which is little else but pure water.

We might be induced to believe that the mineral acids might be concentrated by congelation, as indeed they might be, if they were mixed with a very great quantity of water: but their adhesion to water is so strong, that they cannot be much concentrated by this method.

CXCII. CONDENSATION. By the condensation of a body we ought to understand the approximation of its integrant parts, so that it occupies a smaller space, and that its specific gravity is augmented, without the loss of any heterogeneous matter. For instance, air, forced by compression to confine itself within a narrower space, is to be considered as condensed.

CXCIII. CONE. (x)

CXCIV. CONTRAYERVA. (y)

CXCV. COPAL. (z)

CXCVI. COPPER. Copper, called also by chemists *Venus*, is an imperfect metal of a red shining color. It is harder, more elastic and sonorous, but a little less ductile than silver. It is nevertheless considerably ductile, and may be drawn into wire as fine as hair, or beaten into leaves almost as thin as those of silver.

The tenacity of the parts of this metal is very considerable, since a copper wire, the diameter of which is a tenth part of an inch, is capable of supporting a weight of 299¼ pounds without breaking.

(x) CONE (MELTING). This is a hollow cone formed of copper or of brass, with a handle, and with a flat bottom adjoining to the apex of the cone, upon which it is intended to rest. Its use is to receive a mass of one or more metals melted together and poured into it. This mass when cold may be easily shook out of the cone, from the figure of the vessel. Also if a melted mass, consisting of two or more metals, or other substances not combined together, be poured into this vessel, its figure facilitates the separation of these substances according to their respective densities. The cone ought to be well heated before the melted mass is poured into it, that no moisture may be contained, by which a dangerous explosion might be occasioned. It ought also to be greased internally with tallow, to prevent the adhesion of the fluid matter.

(y) CONTRAYERVA. The leaves of this plant are said to afford a poison employed by Indians for poisoning arrows, to which poison the root of the said plant is said to be an antidote. From an ounce of the root Neuman extracted, with water, three drams and half a scruple; and from the same quantity, with spirit of wine, five scruples and two grains.

(z) COPAL, improperly called *gum opal*, is a hard, shining, transparent, citron-colored, odoriferous, concrete juice of an American tree, but which has neither the solubility in water common to gums, nor the solubility in spirit of wine common to resins, at least in any considerable degree. By these properties it resembles amber. By digestion in linseed oil, with a heat very little less than sufficient to boil or decompose the oil, it may be dissolved. This solution, diluted with spirit of turpentine, forms a beautiful transparent varnish, which, when properly applied, and slowly dried, is very hard and very durable. This varnish is applied to snuff-boxes, tea-boards, and other utensils. It preserves and gives lustre to paintings, and greatly restores the decayed colors of old pictures by filling up the cracks, and rendering the surfaces capable of reflecting light more uniformly.

Copper weighed by the hydrostatical balance loses in water about an eighth or a ninth part of its weight (*a*). It has a very singular and disagreeable smell and taste. It cannot be fused without a violent degree of heat sufficient to make it white.

Copper, being an imperfect metal, may be burnt, destroyed, and calcined by the united action of fire and air: for which reason its quantity is always diminished by melting it without covering its surface.

When it is exposed to a great fire with free access of air, it smokes, loses part of its weight, and communicates to flame beautiful green and blue colors.

It resists more than any other imperfect metal the action of fire before it suffers any considerable alteration. When a clean and polished copper plate is gently and gradually heated, its surface is covered with all the colors of the rainbow. This appearance proceeds from the developement, and the different states of the phlogiston of the metal. (*b*)

When this metal is exposed to red heat with contact of air, its surface becomes quickly tarnished, and its metallic lustre is changed into a dark and earthy appearance; and if this heat be continued during a certain time, the surface of the metal is burnt and destroyed; so that when it cools, it is found to have no longer any adhesion with the uncalcined copper, but to be separated in scales from the difference of the contraction, occasioned by cooling, upon the uncalcined copper, and upon its burnt surface.

When this surface is separated, the copper beneath it seems clean and shining; but it will soon suffer the same change as the former, if it be again heated; and thus a piece of copper may be entirely reduced to scales no longer possessed of brilliancy, ductility, or other metallic properties, and which are called *burnt copper*.

This calcined copper is less fusible than copper in its metallic state: when exposed to a great fire, but a very small quantity of copper is obtained from it; the rest of it is changed into a dark and opake vitrified scoria; except the scales have been mixed with some matter capable of restoring to them phlogiston; in which latter case a quantity of malleable copper is obtained nearly equal to that of the scales employed. *See* Reduction *of* Metals.

These copper scales, which are at first but imperfectly calcined, may be entirely deprived of phlogiston and of their metallic properties by a second calcination under a muffle continued sufficiently long.

(*a*) The specific gravity of European copper is to that of water as 8843, and of Japanese copper as 9000 to 1000.

(*b*) All metals are subject to receive these colors or irises by heat; and from the color of any part of a piece of metal we may discover what degree of heat has been applied to that part, as the same degree of heat always gives the same color to the same metal: hence artists, by observing the colors acquired by steel exposed to fire, are enabled to apply to pieces of that metal the precise degree of heat which they have found by experience to produce the required hardness, in the operation of tempering steel. Thus they know, that the heat which gives a blue color to steel is sufficient to give the requisite hardness for springs. The irises, or different colors given to different parts of one piece of metal, are occasioned by the heat being unequally applied. These colors are produced by a more or less perfect calcination of the surface of the metal exposed to heat.

Copper is alſo affected by the combined action of air and water: hence its ſurface is apt to tarniſh, and even to be covered with a green ruſt, called *verdegriſe*.

This ruſt is copper partly decompoſed, and deprived of part of its inflammable principle; for it cannot be melted into copper without much loſs, excepting its phlogiſton be reſtored by ſome reductive flux. Theſe are alterations to which all the imperfect metals are ſubject. *See* METALS (IMPERFECT).

This metal is eaſily ſoluble by all acids, and its ſolutions are green or blue. (*e*)

Vitriolic acid, although the ſtrongeſt of all, diſſolves copper more difficultly than any other: it muſt be concentrated and aſſiſted by conſiderable heat and time to diſſolve this metal. From this ſolution reſults a neutral ſalt, which forms beautiful blue cryſtals, called *blue vitriol*, or *vitriol of copper*. *See theſe words.*

Nitrous acid diſſolves copper very quickly with violence and effervеſcence; and during the ſolution it takes from the metal part of its phlogiſton. The nitre formed by this ſolution is a very deliqueſcent ſalt. The ſalts formed by marine acid or by aqua regia with copper are alſo very deliqueſcent.

Vegetable acids, and particularly thoſe of wine and of vinegar, may be eaſily united with copper. The former acid forms with it the verdegriſe uſed in painting (*See* VERDEGRISE); and the ſecond, when ſaturated, forms the ſalt called *cryſtals of verdegriſe*, or *cryſtal of Venus*. *See* CRYSTALS *of* VERDEGRISE.

All acids united with copper may be ſeparated from it without any intermediate ſubſtance, and merely by fire.

Calcareous earths, fixed and volatile alkalis, ſeparate copper from any acid, and precipitate it in form of a beautiful green powder. The color of theſe precipitates of copper is cauſed by a portion of the ſalts which remain united with them. As the metal thus diſſolved and precipitated has loſt part of its phlogiſton, particularly when it has been diſſolved by vitriolic and nitrous acids, theſe precipitates of copper cannot be melted into malleable copper without addition of phlogiſton: but if they be melted with glaſſes, or vitreſcible matters, and the fire be properly managed, they communicate their colors to theſe ſubſtances: hence they may be applied to imitate precious ſtones of a green color, or nearly green, as the emerald, and beryl or aqua marina, and for ſeveral ſhades of painting upon pottery and porcelain.

Some metallic matters, which have a ſtronger affinity than copper has to acids, are therefore capable of precipitating this metal from its ſeveral ſolutions. Iron particularly has this property; for which reaſon, if it be added to a ſaturated ſolution of copper in an acid, it will be attacked and diſſolved by this acid, and it will precipitate the copper; and thus the ſolution of copper is changed into a ſolution of iron. While this happens, a remarkable phenomenon appears: the copper thus precipitated is in its metallic ſtate and brilliancy. This effect, which ſeems to be general whenever a metallic matter is ſeparated from an acid by means of another metallic matter, can only happen becauſe the

(*e*) Solutions of copper in vitriolic acid, vegetable acid, oil, or water, are green; that in marine acid is at firſt brown or yellow, and becomes afterwards green; and that in aqua fortis is of a bluiſh-green color: volatile or fixed alkalis make the ſolutions of copper in acids blue: a ſolution of copper in volatile alkali, expoſed to air, is blue.

precipitating metal ſeparates entirely and exactly all the acid from the precipitated metal, which earths and alkalis ſeem incapable of doing; and becauſe the precipitating metal ſupplies enough of phlogiſton to the acid, to prevent the acid from retaining the phlogiſton of the precipitated metal, which earths and alkalis are alſo incapable of doing.

However that be, this precipitation of copper in its metallic ſtate, by the intervention of iron, is capable of impoſing upon, and actually has impoſed upon perſons ignorant of chemiſtry; who, perceiving that a piece of iron, dipt into a liquor in which they ſuſpected no copper, became covered over with copper, imagined that this liquor had the property of changing iron into copper.

This property which iron has of ſeparating copper from acids has been applied to uſe. In England, the water in a copper mine is impregnated with a great quantity of blue vitriol, and from which much copper is extracted by means of iron immerſed in it. In Germany ſome copper ores are ſo pyritous, that they cannot be advantageouſly treated by ordinary fuſions, but are reduced into vitriol, and by means of the iron which is put into the lixivium of this vitriol, called *cement water*, a conſiderable quantity of copper is obtained, which would otherwiſe be loſt. *See* ORES, PYRITES, *and* VITRIOLS.

Copper produces, with reſpect to mercury and ſilver diſſolved in acids, the ſame effects which itſelf ſuffers from iron; that is, it ſeparates theſe metals ſo exactly from the acids with which they are united, that they appear with their metallic luſtre.

This property of copper is employed to obtain ſilver diſſolved by ſpirit of nitre in the operation of parting. This ſilver is generally very pure.

If a very clean plate of copper be immerſed in a ſolution of mercury, particularly if this ſolution have an exceſs of acid, it will be very ſoon covered over with mercury, which adheres to it, and which, when wiped and waſhed, makes a very white and brilliant ſilvering. This alſo is one of the experiments which exhibit an appearance of tranſmutation capable of aſtoniſhing thoſe who are ignorant of chemiſtry. Every day credulous perſons are deceived by tricks no better than this.

No metal is more ſoluble than copper. It is acted upon by almoſt all ſaline and metallic ſubſtances, and probably for this reaſon ancient chemiſts have called it *Venus*, conſidering it as proſtituted to all ſubſtances.

Fixed and volatile alkalis eaſily diſſolve copper, either directly, or ſtill better if it has been previouſly diſſolved in acids. *See* ALKALIS (FIXED *and* VOLATILE).

Moſt neutral ſalts corrode its ſurface, and reduce it into verdegriſe. The ſame effect is produced by all oils and fat matters, from the latent acid which they contain.

Sulphur has conſiderable action upon copper, and even has a greater affinity with it than with any other metal excepting iron: hence it may be ſeparated from almoſt all metals by means of ſulphur, which alſo renders it much more fuſible. Copper is formed into a mineral or pyritous ſtate by union with ſulphur; and if this compound be expoſed to fire, ſo that the ſulphur ſhall be burnt, its acid will act upon the copper, and reduce it to blue vitriol.

Copper

Copper may be easily united with all metals and semimetals, and with them forms allays; of which see the detail at the articles ALLAY, BRONZE, TOMBAC, *and* SIMILOR.

As this metal is combustible, it may be separated from the perfect metals by calcination, which is accelerated by means of lead, as in refining; or by nitre, which generally much accelerates the calcination of all combustible bodies; so that by repeated projections of nitre upon melted gold and silver allayed with copper, the nitre burns the phlogiston of the copper, and reduces this metal into a scoria which floats upon its surface: but the nitre must be added gradually, and but a little at a time, particularly if much copper be in the allay, because the detonation which it occasions is sufficient to dissipate some of the perfect metals. *See* NITRE.

The affinities of copper, according to Mr. Geoffroy, are mercury and lapis calaminaris, or rather zinc; and according to Mr. Gellert, gold and silver. *(d)*

CXCVII. COPPER (WHITE). White copper is an allay of copper, zinc, and arsenic, in certain proportions, and is white as silver. The precise proportions cannot be easily determined, and the allay cannot without difficulty be made, because of the volatility of the two semimetals. Nevertheless, a very beautiful and silver-like white copper is made by some artists, who carefully conceal their method of preparation.

As this allay is not much used, from its very noxious quality, chemists have not considered it; otherwise any of them who knew the management of metals might probably discover it.

The medicinal virtues of copper are treated of under the article BRASS.

CXCVIII. CORAL. *(e)*

CXCIX. CORK. *(f)*

CC. CORK (FOSSIL). *(g)*

CCI. CREAM. This name is applicable to all substances which separate from a liquor, and collect upon its surface; but it is particularly given to the following substances:

(d) Wallerius says, that if a mixture of calx of copper and sal ammoniac be exposed during a certain time to air, from that mass, by distillation with soap, mercury may be obtained; whence he infers, that either mercury is a component principle of copper, or that at least some part of the copper is convertible into it.

(e) CORAL *and* CORALLINE are shells of marine animals of the polypus kind, and possess the same chemical properties as the fresh shells of oysters and other shell-fish, that is, they are calcareous earths impregnated with some animal principles. *See* EARTHS (CALCAREOUS). From sixteen ounces of coral, Neuman obtained by distillation six scruples of a volatile, alkaline, oily spirit, two or three grains of empyreumatic oil, and a residuum containing five scruples and a half of fixed salt, probably sea-salt. The quantities of these component parts were found to vary according to the freshness of the coral analised.

(f) CORK is the bark of a tree of the oak kind, which grows in the southern parts of Europe. From an ounce of cork Neuman extracted, by boiling in water, two scruples; and from the same quantity he obtained, by digestion in spirit of wine, two scruples and two grains.

(g) CORK (FOSSIL), *Suber montanum*. This name is given to a stone which is a species of amianthus, consisting of flexible fibres loosely interwoven, and somewhat resembling vegetable cork. This is the lightest of all stones. By fire it is fusible, and forms a black glass. It possesses the general properties of amianthus. *See* AMIANTHUS.

CCII. CREAM *of* LIME. The cream of lime is that most attenuated part of quicklime, and most approaching to a saline state, which is dissolved by water with which quicklime is slaked, or even in which slaked lime is boiled. This matter separates from lime-water by crystallization during the evaporation of the water; and as water only evaporates at its surface, this earthy crystallization is also formed there. It forms a semi-transparent pellicle, which becomes thicker and thicker till it separates into pieces, and falls to the bottom by its weight in form of scales. The cream of lime has the same properties as slaked lime has. *See* QUICKLIME. (*h*)

CCIII. CREAM *of* MILK. This is the most oily part of milk; which being naturally only mixed, and not dissolved in milk, and being specifically lighter than the other parts, separates from them by rest, and collects on the surface of the milk, from which it is generally skimmed to compleat the disengagement of the oily from the caseous and serous parts, that is, to make it into *butter*. *See* BUTTER *and* MILK.

Cream of milk, which is generally called simply *cream*, is not only an agreeable aliment when recent, but is also useful in medicine as a lenient, when applied to tetters and erisipelas accompanied with pain, and proceeding from an acrid humor.

CCIV. CREAM *of* TARTAR. Cream of tartar is, properly speaking, that part of the concrete acid of tartar which crystallizes first, and like a pellicle on the surface of water in which tartar has been boiled, with intention to purify it, and to separate from it its most saline part. Thus this substance called *cream*, from its manner of formation, does not essentially differ from the crystals of tartar which are formed in the liquor; and these crystals are accordingly, as well as the saline pellicle, generally called cream of tartar, these two matters being confounded together by one name, from which no inconvenience results. *See* TARTAR.

CCV. CRIMSON. (*i*)

CCVI. CROCUS. This Latin word, signifying *saffron*, has been applied as a name to earths of certain metals, which in color somewhat resemble saffron: such particularly are the earths of iron and of copper, each of which is therefore called *crocus*, the first being the *crocus of mars* or *of iron*, and the second *the crocus of copper*: but the word *saffron* is more commonly employed, and particularly applied to the earth of iron. *See* SAFFRON.

CCVII. CRUCIBLE. (*k*)

(*h*) Cream of lime is very different from slaked quicklime. The latter substance is calcareous earth deprived of fixable air, and combined with water: it is caustic, soluble in water, and possesses all the properties of quicklime, from which it differs only in containing a quantity of water. Cream of lime is calcareous earth, which having been deprived of fixable air by calcination, and dissolved by water, is, by exposure to air, again combined with fixable air; by which it is rendered mild, crystallizable, unsoluble in water, and restored to its original state before calcination. *See* AIR (FIXABLE).

(*i*) CRIMSON. A crimson color may be given to silks and woolen cloths by cochineal. *See* COCHINEAL. A less durable crimson may be given by Brazil-wood. For the color called by dyers demi-crimson, the root of madder is mixed with cochineal. *See* RED *and* DYING.

(*k*) *See* POTTERY.

CCVIII. CRYSTAL. Cryſtal, called alſo *rock-cryſtal*, or *natural cryſtal*, is a hard, tranſparent ſtone, of the figure of a priſm with ſix faces, which is terminated at each of its extremities by hexagonal pyramids.

The moſt beautiful rock-cryſtal is that which is perfectly clear, white, and tranſparent. It is frequently cut; and luſtres, vaſes, and toys are made of it, as of other beautiful ſtones. Rock-cryſtals, like the precious ſtones, are of all colors; and they receive their color, as the precious ſtones do, from metallic and phlogiſtic ſubſtances. Some of them are brown, and almoſt black; theſe may be rendered white and tranſparent, by making them red-hot, which muſt be done very gently and gradually, to prevent their cracking, which they are very apt to do as well as other vitrifiable ſtones. *See* EARTH (VITRIFIABLE. (*l*).

(*l*) *Cryſtal*, *rock cryſtal*, or *quartz-cryſtal*, is a tranſparent ſtone of the claſs of earths called by ſome ſiliceous, and by others vitriſiable. Its form is that of an hexagonal priſm, one or both ends of which are terminated by hexagonal pyramids. Some of them conſiſt of theſe two pyramids joined together at their baſes, without any priſm interpoſed. Cryſtal is frequently found adhering to quartz; and, according to Cronſtedt, it is nothing but quartz, which he affirms always aſſumes this hexagonal form, when its accretion or cryſtallization has not been interrupted. Cryſtals are either colorleſs, or colored. Colored cryſtals are called by ſome authors *fluors*. Thoſe which are red are called *falſe rubies*; the violet-colored, *falſe amethyſts*, or, according to Cronſtedt, the *true amethyſts*; the yellowiſh-red, *falſe hyacinths*; the blue, *falſe ſaphirs*; yellow, *falſe topazes*; the greeniſh-yellow, *falſe chryſolites*; the green, *falſe emeralds*; the ſea-green, *falſe beryls*. Some cryſtals are duſky, brown, or blackiſh, but ſtill tranſparent. Cryſtals poſſeſs the general properties of the earths called vitrifiable. *See* EARTHS (VITRIFIABLE). Colorleſs cryſtals reſiſt the moſt violent and long continued fire. *See* Mr. D'ARCET's *Memoir upon Vitrification*, Academy of Sciences, 1766. Moſt of the colored cryſtals are fuſible by violent fire. They probably receive this fuſibility, as well as their color, from metallic ſubſtances. Colorleſs cryſtals may be tinged with various colors, ſo as to imitate precious ſtones. For this purpoſe, Neri, in his *Art of making Glaſs*, directs that pieces of clear cryſtal ſhould be laid upon a mixture of four parts of orpiment, four parts of crude antimony, and one part of ſal ammoniac, placed in a crucible, to which another crucible inverted is well luted: the crucibles are to be placed in a furnace, and ſurrounded with charcoal: after a red heat has been gradually applied, and the fire extinguiſhed, the upper pieces of cryſtal will have acquired a fine golden color, reſembling opals, and variegated with beautiful ſpots: the lower pieces of cryſtal will have acquired a fine color, reſembling that of the ſkins of vipers. He gives another proceſs, in which he directs the cementing mixture to be compoſed of two parts of yellow orpiment, two parts of white arſenic, one part of crude antimony, and one part of ſal ammoniac. He directs alſo, that no bellows or ſtrong current of air ſhould be applied to the fire, by which he ſays, that the cryſtals are apt to be cracked, probably by making the heat too intenſe, and that the crucibles ſhould not be opened till they have been gradually cooled. Cryſtals thus treated reſemble rubies, opals, agates, turquois, marbles, chryſolites. Mr. Pott ſays, that he found the color of ſome cryſtals much improved by repeating the operation. Baptiſta Porta directs, that cryſtals ſhould be colored by keeping them immerſed during four or five hours in a melted mixture of ſulphur, crude antimony, orpiment, arſenic, and tutty. In theſe operations, the cryſtals ſeem to imbibe ſome of the vapors of the metallic ſubſtances. The chief difficulties ſeem to be to prevent the cracks to which the cryſtals are very ſubject by this treatment, and to procure a ſufficient penetration. Probably both theſe purpoſes might be effected by a very ſtrict attention to the gradual application, and to the maintenance of a due degree of heat.

CCIX. CRYSTAL (FACTITIOUS). The word cryſtal has been applied to glaſſes produced by art, which from their tranſparency and whiteneſs imitate rock-cryſtal. In fact, ſome are made as beautiful as the fineſt rock-cryſtals, but not nearly ſo hard. The heat of ordinary vitrification ſeems incapable of producing glaſs as hard as rock cryſtal; nor do our crucibles ſeem capable of ſuſtaining the requiſite heat, if it could be raiſed. *See the method of making cryſtals at the words* GLASS *and* VITRIFICATION.

CCX. CRYSTAL (MINERAL). Mineral cryſtal, called alſo *Salt of Prunella*, is melted nitre detonated with a little ſulphur, and caſt into form of tablets.

Nitre is one of the neutral ſalts which contains the leaſt water in its cryſtallization, or which loſes the leaſt water by a true fuſion, and is alſo one of the moſt fuſible ſalts.

To make mineral cryſtal, very pure nitre muſt be put into a clean crucible, and quickly fuſed, taking care that no aſhes or coal fall in. When the nitre is fuſed, it is to be detonated with ſulphur, in the proportion of a dram of the latter to a pound of the former. It is then to be poured into a copper, or rather a ſilver baſon, in which it is to be agitated while yet fluid, that it may fix in form of cakes or tablets.

No other effect is produced upon the nitre by the ſmall quantity of ſulphur with which it is detonated, than to introduce into it a proportionable quantity of vitriolated tartar, called *Sal Polychreſt of Glaſſer*. In all other reſpects, chemical and medicinal, mineral cryſtal is nitre, and may be given like this, from four grains to ten or twelve, in a quart of proper drink. It is cooling, ſedative, aperitive and diuretic. This preparation then ſeems uſeleſs, ſince the ſame intentions may be better accompliſhed by well purified nitre. *See* NITRE.

CCXI. CRYSTALLIZATION. This word is ſometimes employed to ſignify ſubſtances which are cryſtallized, or whoſe parts are ſo arranged that they form regular figures. In this ſenſe, we ſay *ſtony cryſtallizations*, *pyritous cryſtallization*, &c.

CCXII. CRYSTALLIZATION *of* SALTS *and of other Subſtances*. If the word cryſtallization were to be confined to its moſt proper ſenſe, as it ſeems to have been formerly, it could only be applied to operations by which certain ſubſtances are diſpoſed to paſs from a fluid to a ſolid ſtate by the union of their parts, which ſo arrange themſelves that they form tranſparent and regularly figured maſſes, like native cryſtal; from which reſemblance the word cryſtallization has evidently been taken.

But modern chemiſts and naturaliſts have much extended this expreſſion, and it now ſignifies a regular arrangement of the parts of any body which is capable of it, whether the maſſes ſo arranged be tranſparent or not. Thus opake ſtones, pyrites, and minerals, when regularly formed, are ſaid to be cryſtallized, as well as tranſparent ſtones and ſalts.

The opacity and tranſparency of ſubſtances are juſtly diſregarded in conſidering whether they be cryſtallized or not; for theſe qualities are perfectly indifferent to the regular arrangement of the integrant parts of ſubſtances, which is the eſſential object of cryſtallization.

This being eſtabliſhed, cryſtallization ought to be defined an operation by which the integrant parts of a body, ſeparated from each other by the interpo-

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fition of a fluid, are difpofed to unite again and to form folid, regular, and uniform maffes.

To underftand as much as we can of the mechanifm of cryftallization, we muft remark,

1. That the integrant parts of all bodies have a tendency to each other, by which they approach, unite, and adhere together, when not prevented by an obftacle.

2. That in fimple, or little-compounded bodies, this tendency of integrant parts is more obvious and fenfible than in other more compounded: hence the former are much more difpofed to cryftallize.

3. That although we do not know the figure of the primitive integrant molecules of any body, we cannot doubt but that the primitive integrant molecules of every different body have a conftantly uniform and peculiar figure.

4. That thefe integrant parts cannot have an equal tendency to unite indifcriminately by any of their fides, but by fome preferably to others, excepting all the fides of an integrant part of a body be equal and fimilar; and probably the fides, by which they tend to unite, are thofe by which they can touch moft extenfively and immediately. The moft general phenomena of cryftallization may be conceived in the following manner.

Let a body be fuppofed to have its integrant parts feparated from each other by fome fluid. If a part of this fluid be taken away, thefe integrant parts will approach together; and as the quantity of intervening fluid diminifhes, they will at laft touch and unite. They may alfo unite, when they come fo near to each other that their mutual tendency fhall be capable to overcome the diftance betwixt them. If, befides, they have time and liberty to unite with each other by the fides moft difpofed to this union, they will form maffes of a figure conftantly uniform and fimilar. For the fame reafon; when the interpofed fluid is haftily taken away, fo that the integrant parts fhall be approximated, and be brought into contact before they have taken the pofition of their natural tendency, then they will join confufedly by fuch fides as chance prefents to them; they will in fuch circumftances form folid maffes, whofe figures will not be determinate, but irregular and various.

In every cryftallization all that we have defcribed may be obferved.

If cryftallization be taken in the general fenfe we have given to it, ice is a true cryftallization. Water, for inftance, is to be confidered as a body whofe integrant parts are feparated from each other by the interpofition of the matter of fire. Melted metals are alfo to be confidered in the fame manner. The fluidity of thefe bodies is to be attributed to this matter of fire, with which thefe bodies are penetrated. When therefore thefe liquefied bodies cool, which can only be by taking away this igneous matter which penetrates them; if the approximation of the integrant parts, which is a neceffary confequence of this cooling, be made fo flowly that they fhall have time and liberty to unite by the fides moft difpofed to this union, they will always form maffes of a conftant and fimilar figure.

Thus when water freezes flowly, and is not agitated by any motion which can difturb the order in which the integrant parts tend to unite, it forms regular cryftals of ice, and always of the fame form.

These crystals which may be called crystals of water, are long, needle like masses, flattened on one side, joined together in such a manner that the smaller are inserted into the sides of the greater; and thus these compound crystals have the appearance of feathers, or of leaves of trees.

The most remarkable circumstance attending this crystallization is, that the angle formed by the insertion of the smaller needles into the sides of the larger ones is always of the same width, that is, sixty degrees. However, it is sometimes double, that is, 120 degrees; but it is constantly one of these two angles, and it is to be remembered that these angles are complements to each other, that is, they are together equal to two right angles. We are obliged to Mr. Mairan for these fine observations, which he has given at full length in an excellent dissertation on ice.

Metals, sulphur, and several other bodies not much compounded, which fix and become solid after fusion, assume always a regular arrangement whenever they are slowly enough cooled for that purpose. The star of the regulus of antimony has been long observed with wonder. Alchemists, who saw wonders in all their operations, considered this star as something mysterious and significant; but the wonder ceased when the cause of it was investigated by so good a philosopher as Mr. Reaumur, and discovered to be the tendency which the integrant parts of the regulus of antimony have to arrange themselves in an uniform manner; for this arrangement always happens, when the regulus of antimony has been well fused, and slowly cooled. Mr. Macquer and Mr. Beaumé having fused silver with great heat, and afterwards very slowly cooled it, observed that this metal also arranged itself in a regular manner. Mr. Beaumé observed the same effect upon applying to all the other metals and semi-metals the same treatment. Every metallic substance was found to have its peculiar form, which Mr. Beaumé proposes to determine.

What we have said concerning bodies, which being fused by fire, are crystallized when they become solid by cold, may also be applied to all those whose integrant parts swim separately from each other in a fluid such as water. Thus all kinds of earths, and of metallic and mineral matters, which are found in that state, may be crystallized by taking away some of the watery fluid which separates their integrant parts. A slow evaporation of the water which contains these substances allows their parts to approximate and to unite together by the most suitable sides, and to form masses of a determinate and constant figure.

In this manner are formed the crystallizations of precious stones, of rock crystal, of spars, of certain stalactites, and of all stony bodies found so frequently well crystallized. The regular forms of most pyrites, of many ores and metallic minerals, and even of some pure metals, such as gold, silver, copper, which are found regularly arranged and ramified, ought to be attributed to the same mechanism, that is, to the slow separation of their integrant parts from the water in which they are suspended.

But of all the substances thus susceptible of crystallizing by their separation from water, salts are most disposed to it, and afford the best examples of crystallization; because all saline substances being essentially soluble in water, are liquefied by this fluid in a much greater quantity than the bodies we have mentioned, which, properly speaking, are only miscible with water.

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This property which salts have of being soluble by water must depend on a certain affinity or adhesion of their integrant parts to those of water; and from this adhesion we can deduce the phenomena peculiar to the crystallization of salts, and the differences observable betwixt the crystallization of these, and that of other substances to which water has not the same affinity. We shall relate what is most necessary to be known concerning the crystallization of salts, an object of great importance in chemistry.

The crystallization of a salt dissolved in water may be procured, as evidently appears from what we have said, by taking away the dissolving water: and as most salts are less volatile than water, and may even be considered comparatively as fixed substances, this substraction may be commodiously made by the evaporation of a sufficient quantity of water. The parts of the salt, being sufficiently approximated by this evaporation, will unite together and form crystals, as we have already explained concerning other substances. But as the saline parts adhere to those of the water, this circumstance occasions an essential difference in the crystallization; which is, that the salt when crystallizing, does not separate itself from all the water with which it was united in solution, but retains some part of it with some force; and this portion of water adhering to, and even combined with the parts of salt, makes with it one whole or entire body; whence saline crystals are compounded of crystallized salt, and of water which makes part of these crystals. This water is called by chemists the *water of crystallization.*

As this water of crystallization is superabundant to the essence of the crystallized salt, it may be taken from it by evaporation with a certain degree of heat, without any change produced upon the essential properties of the salt; so that it may be again dissolved and crystallized as at first. But we must observe, that the water of crystallization cannot be taken from any salt without destroying the form, or at least the consistence and transparency of the crystals; and when the salt is to be re-dissolved and re-crystallized, it retains in this second crystallization the same quantity of water precisely as it had in the first.

Hence we ought to conclude that this water of crystallization is not essential to a salt, as a salt, but that it is essential to a salt as being crystallized; since to it the saline crystals owe their form, transparency, and even the cohesion of their parts.

The quantity of water of crystallization varies much in different salts. Some of these, as alum, Glauber's salt, and martial vitriol, contain about half their weight of water; and others, as nitre and sea salt, contain but a small quantity. Selenites contains an almost insensible quantity of water. This difference seems to depend on the state of the acid in these salts; and in general the more firmly an acid is combined with its basis, the less water it retains in crystallization.

A very important remark to be made upon this water of crystallization, is, that when the crystallization is properly managed, this water is perfectly pure, and contains no substance foreign to the crystallized salt. To Mr. Beaumé we owe this discovery. By many experiments he was convinced that no neutral salt, with a basis of fixed alkali, retains in its crystals either superabundant acid or alkali, or any other matter foreign to the neutral salt, although even this

falt had been cryftallized in a liquor that was acid, alkaline, or impregnated with any other fubftance foreign to the falt; and that if fometimes thefe heterogeneous fubftances are found included in faline cryftals, they have no adhefion to them, fince they may be feparated merely by draining upon brown paper, without any change produced upon the cryftals of the falt; whereas the water of cryftallization cannot be taken away without a deftruction of the cryftals. The caufe of this phenomenon will eafily appear when we recollect that falts retain the water of their cryftallization by the adhefion of thefe falts to water; and that if a falt be diffolved in water impregnated with acid, alkali, or other fubftance foreign or fuperabundant to the falt diffolved, this falt does not adhere either to the fuperabundant acid, or alkali, nor to the other extraneous fubftances, but to the water alone.

Evaporation of water, in which a falt is diffolved, is not the only method by which the falt can be cryftallized. Another method which may be ufed with fuccefs, at leaft for the cryftallization of moft falts, is by application of cold to the water fufpending the falt. The reafon of this is as follows.

All falts are foluble in water, but not with equal facility, fome of them requiring much water, and others very little: moft of them are more eafily diffolved, and in greater quantity, by hot than by cold water; and others with nearly equal facility, and in equal quantity by both hot and cold water. This being eftablifhed, when boiling water, that is, water heated as much as poffible, fufpends in folution all that it can diffolve of thofe falts which are more foluble by hot than by cold water, if this water be cooled, the portion of falt which was diffolved merely by the heat of the water, will be collected and cryftallized as faft as the water cools. We may alfo obferve, that when this cooling of the water is very quick, the cryftals it occafions are fmall, irregular, and ill-fhaped; and that the more flowly the cooling is produced, the larger and better formed the cryftals are.

What has been hitherto faid concerning the regular forms taken by certain liquefied matters during their fixing or becoming folid, is entirely applicable to this kind of cryftallization of falts. This cryftallization is not effected by a fubftraction of water but of fire, by which fubftraction a condenfation of the faline liquor is produced, and confequently a fufficient approximation of the parts of the diffolved falt to difpofe them to unite, and to form cryftals; and as in this cafe, the fluidity or the folidity of the falt is folely occafioned by the prefence or abfence of the matter of fire, thefe falts diffolved by heat, and cryftallized by cold, may be compared to melted metals, the parts of which are regularly arranged by a flow cooling. But with regard to falts we muft obferve, that as their cryftallization is performed in a fluid to which they have an adhefion, they retain the fame quantity of water of cryftallization, whether the operation was performed by cold or by evaporation.

Hence we may perceive, that evaporation and cooling are the two principal methods of cryftallizing falts. Sometimes it is proper to employ one only of thefe methods, and at other times both together, according to the particular nature of the falt to be treated. If it be one of thofe falts which are better cryftallized by cooling than by evaporation, fuch as nitre, for inftance, then the former method ought to be ufed; for nitre cannot be well cryftallized by evapo-

evaporation alone, because the water which keeps it dissolved would be reduced almost to nothing before the crystallization would begin, and the liquor would be so concentrated that the parts of the salt would not arrange themselves properly.

When, therefore, nitre is to be crystallized, the water is to be evaporated so far only that when it cools crystals shall be formed. This degree of evaporation is known by taking a few drops of the hot liquor, and cooling them quickly; if the evaporation has been sufficient, small crystals may be perceived instantly formed. As the evaporation here mentioned does not occasion the crystallization of the nitre, but is only preparatory to it, this evaporation may be either quick or slow without inconvenience. The liquor may be made to boil as fast as possible, and the crystals of nitre will be no less perfect, provided that this liquor when sufficiently evaporated be slowly cooled: when it is perfectly cooled, no more crystals will be formed in it. It ought then to be poured off, and again evaporated, when by a second cooling it will furnish more crystals, and this treatment is to be continued to the end.

But if well formed crystals are to be obtained of one of those salts which are nearly as soluble in cold as in boiling water, and which consequently cannot be crystallized by cold, evaporation is the only method to be used. Common salt is a proper instance of this kind.

Water impregnated with common salt must be evaporated to obtain crystals; and when the liquor contains much more water than is necessary to the solution of the salt, the evaporation may be carried on as fast as possible till the crystallization is ready to begin. This point is known by a thin, saline pellicle, which floats on the surface of the liquor, and seems as if dust had fallen upon it. This pellicle is composed of the first portions of salt beginning to crystallize. It is always formed at the surface; because this salt crystallizes by evaporation only, and evaporation is only at the surface.

Mr. Rouelle, in his Memoir concerning the Crystallization of Sea-salt, says, that he has observed, that when the evaporation has been very slow, and with a heat not much exceeding that of summer, the crystals of common salt are formed at the bottom and not at the surface of the liquor. As this appears quite contrary to the manner in which this salt crystallizes in all other circumstances, have we not reason to believe, that in this insensible evaporation the crystals of sea-salt are formed first at the surface, as in all other evaporations, but that they cannot be perceived from the extreme smallness of their size at first; and because the heat is too weak to dry their upper surface, and to make them adhere to the air, these small crystals fall to the bottom without being perceived, and there become larger by the union of other small crystals, formed and precipitated in the same manner?

If the evaporation when brought to the point of crystallization was to be stopt, and the liquor to be cooled after it has been filtrated, and put into a bottle to prevent further evaporation from the remaining heat, scarcely any crystals would be formed in it, but the salt would remain dissolved in the water. If, on the contrary, the evaporation should be hastily continued, salt would indeed be formed in great quantity; but as its parts would not have time to

arrange themſelves properly, the cryſtals would be ſmall and ill-formed *. The evaporation therefore ought to be continued, but ſlowly: and by this method very beautiful cryſtals will be obtained, partly in cubes, partly in hollow pyramids formed by cubes †.

The rules of cryſtallization moſt ſuited to the nature of each ſalt muſt be obſerved, not merely to obtain well-formed cryſtals; for if their figure was once determined, the regularity of their cryſtallization would be afterwards of no conſequence: but the cryſtallization of ſalts relates to an affair of much more importance, which is their purity.

We have already ſaid, that, when a ſalt is well cryſtallized, the water of its cryſtallization is very pure, and contains none of the heterogeneous matters which happened to be mixed with the ſolution of the ſalt before cryſtallization. This obſervation may be extended to other ſalts which may happen to be diſſolved in the ſame liquor. If then ſeveral ſalts be diſſolved together, we may almoſt always ſeparate them exactly from each other, by cryſtallizing each of them according to their character; for amongſt the almoſt infinite number of ſalts now known, ſcarcely two ſhow preciſely ſimilar phenomena in cryſtallization. We may, from the example of ſeparating nitre and common ſalt when diſſolved together in the ſame liquor by cryſtallization, ſhow how ſuch ſeparation may be done in general, even when ſeveral ſalts happen to be ſo confounded. This is certainly one of the fineſt and moſt uſeful problems in chemiſtry.

Let us then ſuppoſe that nitre and ſea-ſalt, diſſolved in the ſame liquor, are to be ſeparated from each other. The method of effecting this will appear evidently from conſidering what we have ſaid concerning cryſtallization; and this method will be found to conſiſt in employing alternately evaporation and cooling. Firſt of all then, the liquor muſt be evaporated. If, during the evaporation, a pellicle appears on the ſurface, and no cryſtals of nitre appear in a ſmall quantity of the liquor when haſtily cooled, then we diſcover that common ſalt is in greater quantity than the nitre. In this caſe the evaporation muſt be continued, and the common ſalt ſeparated as faſt as it is formed, till a ſmall quantity of the liquor, when haſtily cooled, ſhews ſmall needle-like cryſtals of nitre;

* Although cryſtals of ſea-ſalt are generally leſs regular when formed by a haſty than by a ſlow evaporation, this irregularity is, however, leſs ſenſible in this ſalt than in moſt others, and its cryſtals always tend to a cubic form, or at leaſt appear compoſed of cubes. From this obſervation we have reaſon to believe that the primitive integrant molecules of this ſalt are cubes: hence we may conceive that as all the ſides of this ſalt are equal and ſimilar, from their union regular ſolids ought to reſult, more or leſs approaching to the cubic figure, by whatever ſide they may have been united. *Note of the Author.*

† Although in a moderate evaporation a very large quantity of cryſtals of common ſalt is formed in quadrangular, hollow, and inverted pyramids, the cubic figure is nevertheleſs the primitive and eſſential form of this ſalt; for theſe pyramids are all compoſed evidently of cubes. Beſides, they are only formed accidentally, by the union of ſeveral quadrangular priſms compoſed of cubes, which are ſucceſſively applied to the ſides of a firſt cube; which being formed at the ſurface of the liquor, remains ſuſpended there, by the adheſion of its upper dried ſurface to the air. As this cube is beſides a little ſunk into the liquor by its weight, ſo that the liquor riſes along its ſides, it becomes by that means a very proper foundation for the formation of this pyramid. This mechaniſm is explained at length in Junker's book, and in a Memoir of Mr. Rouelle concerning the cryſtallization of ſea-ſalt, printed in 1745. *Note of the Author.*

nitre; then the liquor is to be left to cool, that the nitre may have an opportunity of cryſtallizing by cooling; after which the evaporation is to be reſumed that more common ſalt may be ſeparated, and to diſſipate ſo much water that cryſtals of nitre ſhall again be formed by cooling. Thus theſe ſalts may be alternately cryſtallized, one by cooling and the other by cryſtallization, till they are entirely ſeparated.

If, in the beginning of the operation, the liquor had, upon trial in ſmall quantity, given cryſtals of nitre by cooling, before any pellicle had appeared upon its ſurface, the common ſalt would then have been known to be in much leſs quantity than the nitre. In this caſe, the nitre would have been cryſtallized firſt, but always by cooling. The quantity of nitre, which exceeds that of common ſalt, having been thus ſeparated, the common ſalt would then begin to cryſtallize in its turn by evaporation.

Several eſſential remarks are to be made upon this ſeparation of ſeveral ſalts from each other by cryſtallization.

Firſt, although the two ſalts, the method of ſeparating which we have given as an example, are the moſt capable of ſuch a ſeparation, becauſe ſea-ſalt is one of the ſalts which are leaſt of all to be cryſtallized by cooling; and on the contrary, nitre is one of thoſe which are beſt cryſtallized by this method; nevertheleſs, after a firſt cryſtallization of theſe two ſalts, ſuch as we have deſcribed, they are not entirely and perfectly ſeparated from each other: the ſea-ſalt contains ſome nitre, and the nitre contains ſome portion of ſea-ſalt; becauſe in cryſtallization one ſalt always takes with it a ſmall portion of another: but when two ſalts are ſo different from each other in this reſpect as theſe two, a perfect ſeparation may be eaſily made by diſſolving each of them ſeparately in more water, and by proceeding to their cryſtallization by the ſame method. As a new ſeparation is made by each cryſtallization, they may be obtained at laſt perfectly pure by repeating ſufficiently this management.

The ſecond remark to be made on the ſeparation of ſalts by cryſtallization is, that this ſeparation is ſo much more difficult and long, in proportion as the ſalts to be ſeparated are more ſimilar to each other in their manners of cryſtallization. For inſtance, if two ſalts, which are only capable of cryſtallizing by evaporation, as ſea-ſalt and vitriolated tartar, or by cooling, as nitre and Glauber's ſalt, they cannot be ever obtained quite pure and ſeparated from each other by any management: nevertheleſs, even in this caſe they may be in great meaſure ſeparated; firſt, becauſe the preciſe degree of evaporation, or of cold, which is neceſſary for the cryſtallizing of one ſalt, is generally ſomewhat different from that which is requiſite for the cryſtallization of another ſalt; ſecondly, becauſe although they ſhould reſemble each other much in this reſpect, ſome differences, which muſt be obſervable in the ſize and form of their cryſtals when well formed, will furniſh means of making at leaſt an imperfect ſeparation, which may be made more perfect by repeating this management.

But the ſeparation of ſome ſalts is attended with ſingular and even inſuperable difficulties. Such are the ſalts which have ſome action upon each other, and the parts of which have ſome adheſive power together. This action of neutral ſalts upon each other has been very little obſerved: it is, nevertheleſs, very ſenſible in ſome of them; ſuch are ſal ammoniac and corroſive ſublimate, which not only act as intermediate ſubſtances to each other, by which they can be

diſſolved

diſſolved in greater quantities in water and in ſpirit of wine than they can ſingly, but which being diſſolved together in the ſame menſtruum, cannot be again cryſtallized ſeparately by any method; as Mr. Macquer has ſhewn in his Memoir concerning Mr. Garay's Tincture of Mercury, printed in the Collection of the Academy for the year 1755.

Some ſalts have ſo great affinity with water, and are ſo ſoluble by this menſtruum, that they can ſcarcely be cryſtallized. The ſolution of theſe ſalts requires to be evaporated almoſt to dryneſs, or to a thick conſiſtence, and then by cooling they generally form needle-like cryſtals applied longitudinally or tranſverſely to each other. When they are expoſed to the air, they attract humidity, and reſolve into a liquid ſtate. Mr. Rouelle was the firſt who deſcribed, in his Memoir concerning Salts in the year 1744, the cryſtallization of deliqueſcent ſalts, ſuch as marine ſalt and nitre with baſes of calcareous earth, of copper, and of iron, terra foliata tartari, and the ſalts formed by the union of the acids of vinegar and of tartar with iron and with copper.

All theſe ſo difficultly cryſtallizable ſalts may be eaſily ſeparated from ſalts which may be readily cryſtallized, with which they happen to be mixed; becauſe the former ſalts in the evaporations and coolings are always the laſt to cryſtallize.

Two of theſe ſalts, namely nitre and marine ſalt, with baſes of calcareous earth, are found mixed with nitre and marine ſalt with baſes of fixed alkali; both of them in the lixiviums of the manufacturers of nitre, and the latter in almoſt all the waters in which common ſalt is found to be naturally diſſolved: hence, when the proper operations are made to obtain nitre and ſea-ſalt, after all the evaporations and cryſtallizations, a very heavy ſaline liquor remains from which no cryſtals can be procured, called the *mother water*. Theſe mother-waters of nitre and of common ſalt are, then, nothing but theſe ſalts with earthy baſes almoſt pure; and if a cryſtallization of them were required, the method deſcribed by Mr. Rouelle in the quoted Memoir ought to be practiſed. But this is not a matter worthy the attention of the manufacturers, to whom the perfect purification of nitre and of ſea-ſalt, from an adhering portion of the ſalts with earthy baſis, is of much more importance, as we ſhall ſee when we ſhall treat of theſe ſalts.

Chemiſts have given much attention to this ſubject, the cryſtallization of ſalts; and particularly Mr. Rouelle has made many intereſting reſearches concerning it, which may be ſeen in his Memoir of 1744. But nevertheleſs, much remains yet to be done. The true form of all cryſtallizable ſalts, and the beſt methods of cryſtallizing them, are not yet determined; which will not appear ſurpriſing to thoſe who underſtand this ſubject, and who know that one and the ſame ſalt, although conſtantly tending to the ſame form, is nevertheleſs capable of diſguiſing itſelf in many ways, and of taking many different forms, according to the circumſtances during cryſtallization. The quickneſs or ſlowneſs of evaporation, the quantity of water evaporated, the more or leſs haſty cooling, and the different degrees of cold applied, the ſtate of the air and of the liquor with reſpect to reſt or motion, even the form and matter of the veſſel in which a ſalt is cryſtallized, are ſo many cauſes, which, acting ſucceſſively or together in many different ways, are capable of producing numberleſs varieties in the cryſtallization.

Of all the causes which we have mentioned, capable of varying crystallizations, the nature of the vessel employed seems to deserve least our attention; yet this may produce some change from the greater or less adhesion which the salt may have to the several matters of which these vessels are made. For instance, we can only attribute to the adhesion of salts to the sides of the vessels employed the property which most of them have to branch out in various manners; and to creep along the sides of these vessels, particularly when the crystallization is very slowly performed, so considerably that they frequently go even on the outside of the vessels. Mr. Beaumé has prevented this phenomenon by hindering the adhesion of the salts to the sides of the vessels, by rubbing these sides with some oil.

From what has been said concerning the action of neutral salts upon each other we may conceive, that when such salts happen to be mixed together, they must produce considerable differences in crystallizing.

Many other important observations might be made on the crystallization of certain salts, but they will be better placed under the articles of the several salts which they concern. We are obliged also to leave to the understanding and reflection of our readers to draw from what we have said many corollaries, the detail of which would be too long. We shall only mention a manner of crystallizing salts which is different from the methods by evaporation and by cooling, but which consists also in taking away from the salt a portion of water which keeps it dissolved. This method of crystallization is well effected by adding to a solution of a salt a sufficient quantity of a substance which has no action upon that salt, but which has greater affinity than it with the water which keeps it dissolved. Spirit of wine, for instance, has these properties with regard to many salts. Thus by adding a sufficient quantity of rectified spirit of wine to a strong solution of Glauber's salt, of vitriolated tartar, or of sea-salt, this spirit of wine seizing the water necessary for the solution of the salts, obliges them to crystallize immediately: but as this crystallization is very hastily made, and almost instantaneously, the crystals are always very small and ill-formed. In this respect they resemble the crystals of salts produced from a liquor which contained too little water to keep them dissolved. This happens, for instance, when a strong solution of alkaline salt is combined with concentrated vitriolic acid, to form vitriolated tartar; for this salt, which requires much water to keep it dissolved, does not find enough in the liquor, and appears immediately in form of very small crystals like sand. The same thing may be said of vitriols of silver and of mercury, of luna cornea, and of other metallic salts of this kind produced by adding vitriolic or marine acids to the white metals dissolved in nitrous acid. These salts appear immediately as precipitates, whenever they do not find water enough in the liquors to dissolve them; and Mr. Rouelle justly observes, in his Memoir, that they are not precipitates, but true salts, which not finding water sufficient for their solution, are obliged to be immediately crystallized, but in crystals so small, from the rapidity of their crystallization, that they cannot be known to be crystals but with the help of a microscope.

Notwithstanding what has been said concerning the irregularity of the crystals procured by adding a substance, which seizes the water of the solution of salts, yet if this addition was managed and gradually made, perhaps it might produce very beautiful and very regular crystals. Mr. Beaumé has actually observed

that when salts were crystallized in acid or alkaline liquors according to their nature, their crystals were infinitely larger and more regular than they would have been without this circumstance. *Vegetable salt*, for instance, and *salt of Saignette*, require to be crystallized in an alkaline liquor; and *sedative salt* requires an acid liquor, when it is obtained from borax by the intervention of an acid, if we desire to have fine crystals of these salts. The cause of this must be, that acids or alkalis, having in general more affinity with water than neutral salts have, diminish the adhesion of these neutral salts with the water of the solution; for a too great adhesion of a salt to water may evidently be a great impediment to its crystallization. *See the words* SALT, SALTS (NEUTRAL), *and the several sorts of neutral salts under their respective names.*

CCXIII. CRYSTALS. All neutral salts with metallic bases susceptible of crystallization are commonly called by chemists *Crystals*, when they are actually crystallized; and the name of the metal contained in the salt is added to distinguish it. Thus we say, *crystals of gold*, *of silver*, *of copper*, *of lead*, &c. But as these names do not indicate the acid contained in each salt, they ought to be disused. Here we shall only mention two of these salts called crystals; because they are almost always distinguished by that name. These are the *crystals of silver*, and *crystals of verdegrise* or *of copper*.

CCXIV. CRYSTALS *of* SILVER, or LUNAR CRYSTALS. Crystals of silver are neutral salts with metallic bases composed of nitrous acid saturated with silver. When very pure silver is dissolved by very pure nitrous acid, if the acid be strong, crystals will be perceived merely by the cooling of the solution. These crystals are white, flattened like thin scales, and not very hard. When the nitrous acid used to dissolve the silver is weak, no crystals are formed; because the water in the acid is sufficient to keep the newly formed salt dissolved; but lunar crystals may easily be obtained from this dilute solution by evaporating the superabundant water, and letting the liquor cool.

Very beautiful and white lunar crystals may also be obtained, although the silver employed be allayed with copper or iron: because the salts formed by these two metals with nitrous acid are deliquescent, and are not so easily crystallizable as the salt with basis of silver. In this case the solution ought to be evaporated, if it be necessary; and the crystals of silver will be crystallized by cooling, while the copper or iron will remain dissolved. When the colored liquor is poured off, crystals willl be found sufficiently white and almost pure; but to purify them perfectly, they ought to be drained, dissolved again in very pure water, and again crystallized: then after they are well drained from the liquor, they will be found perfect and beautiful. This even is a method of separating silver from the alloy of copper, or of iron; and of obtaining from standard silver, or silver allayed with copper, as fine and colorless a solution as if tested silver had been employed.

Lunar crystals then are a true *lunar nitre*, or *nitre with basis of silver*; and they accordingly have the property of deflagrating upon burning coals, almost as well as nitre, with basis of fixed alkali. When this experiment is made, silver is found after the detonation incrusted upon the surface of the coal in its metallic state.

Notwithstanding this property which lunar nitre has of detonating with coals, a property which shews a strong adhesion of nitrous acid with silver; yet this adhesion

adhesion is not sufficiently strong to resist a certain degree of heat; so that by calcination or distillation these two substances may be disjoined.

Lunar crystals may be melted with a very gentle, and less than a red heat. They easily lose the water of their crystallization, and then congeal into a black mass, which is generally cast into moulds, and is called *Lapis infernalis*, or *lunar caustic*. *See* CAUSTIC (LUNAR).

This salt is very caustic, as the effects of the lunar caustic shew in surgery, although it has lost a part of its acid in the fusion which it receives. This corrosive quality of lunar crystals seems to render it unfit for internal use as a medicine; yet some physicians prescribe it as a powerful evacuant of water. Boyle, though not a physician, but assisted by some persons of the faculty, proposes a method of rendering these crystals of silver milder, and boasts much of them as a remedy. His method consists in adding to a solution of them in water another solution of an equal quantity of nitre, and evaporating the whole to dryness and whiteness, with a very gentle fire, by which a portion of the spirit of nitre is intended to be taken away without fusing the saline mass; after which, this saline powder is to be made into pills, by forming it into a paste with some bread and water.

Little skill in chemistry is requisite to shew, that nitre thus mixed with lunar crystals, being incapable of acting upon it, cannot render it milder, but must leave it unchanged.

Secondly, by the manner of drying this mixture of lunar crystals and nitre, less of the causticity of these crystals is destroyed than by forming them into lunar caustic, in which operation they sustain a heat sufficient to fuse and to blacken them, and consequently lose more of their acid. After these considerations, we cannot believe that this remedy of Mr. Boyle is so mild and innocent as it has been represented. This is certain, that, notwithstanding the praises given it by this philosopher, its use has not yet been established in medicine.

Lunar crystals are called by Lemeri *vitriol of silver*; but as they contain no vitriolic acid, this name does not suit them, and ought only to be given to the salt formed by the union of vitriolic acid with silver. *See* SILVER.

CCXV. CRYSTALS *of* COPPER, or *of* VENUS. By these names is meant a salt formed by the union of the acid of vinegar with copper.

This combination may be made by dissolving directly copper in good distilled vinegar; but it is made much more commodiously, and more expeditiously, when the copper employed has been previously formed into verdegrise; because the copper in the verdegrise is already divided and penetrated by a certain quantity of acid of wine: verdegrise therefore is always used for the preparation of crystals of copper.

This operation is very simple. It consists in dissolving verdegrise in good distilled vinegar till this acid be saturated. For this purpose a matrass is to be used, and to be set in a sand-bath with a gentle heat. When the vinegar dissolves the verdegrise, it takes a fine greenish-blue color. Some chemists call it also Tincture of Venus. When it ceases to act on the verdegrise, it is to be decanted, evaporated, and crystallized. The beautiful greenish-blue crystals formed are crystals of copper. When this salt is exposed to a dry air, it loses easily the water of its crystallization, and its surface is reduced to a lighter-colored sea-green powder.

The acid of vinegar does not ſtrongly adhere to the copper in this combination. It may be entirely ſeparated from it by diſtillation; and as it had loſt moſt of its ſuperabundant water when it united with the copper, it may by this method be obtained in its greateſt concentration. It is called *radical vinegar*, and improperly *ſpirit of Venus*. See *theſe words*.

The principal intention of chemiſts in making cryſtals of Venus is to obtain radical vinegar. But this preparation is alſo uſed by painters; for which reaſon large quantities of it are manufactured, and it is generally ſold under the name of *diſtilled verdegriſe*; probably becauſe diſtilled vinegar is employed in its compoſition. *See* COPPER *and* VINEGAR.

CCXVI. CUCURBIT. A cucurbit is a chemical veſſel employed in diſtillation, when covered with its capital or head. Its name comes from its lengthened ſhape, by which it reſembles a gourd: ſome cucurbits, however, are ſhallow and wide-mouthed. Cucurbits are made of copper, tin, glaſs, and ſtone-ware, according to the nature of the ſubſtances to be diſtilled. A cucurbit provided with its capital conſtitutes the veſſel for diſtillation called *Alembic*. See *this word, and* PLATES.

CCXVII. CUPEL. A cupel is a wide-mouthed earthen veſſel, like a flat cup, from which reſemblance it has been named.

The uſe of cupels is to contain gold and ſilver mixed with lead in the operations of refining and of eſſay, and to abſorb the litharge and other ſcorified matters formed in theſe operations.

For this reaſon cupels ought to be made of dry, porous earths capable of reſiſting the action of ſtrong fire, and of fluxes.

The aſhes of wood and of bones are the moſt proper earths for cupels. Theſe aſhes ought to be perfectly burnt and calcined; that is, till they become white, ſo that they contain no more inflammable principle, which might revivify the ſcorified metals, and occaſion an ebullition during the operation. They ought alſo to be well lixiviated, and deprived of all ſaline matter, to avoid their fuſion.

To form cupels, aſhes thus prepared ought to be mixed with water into a paſte, to which a proper form is given by means of a mould. Sometimes they are made into a paſte with ſome beer; a ſmall quantity of clay is added, that they may be moulded more conveniently. *Roaſting teſts* made of clay are alſo called by ſome artiſts *cupels*; becauſe they have the ſame form as the refining and eſſay cupels. *See* ESSAY, *and* PLATES.

CCXVIII. CUPELLATION. Cupellation is an operation by which gold and ſilver are refined or eſſayed by ſcorification with lead upon the cupel. *See* REFINING *and* ESSAY.

CCXIX.

D.

CCXIX. **D**AMPS. These are noxious and even fatal exhalations or vapors, which infest subterranean places, and particularly mines, if the air be not frequently renewed.

The instances of fatal accidents caused by these vapors are too frequent. Most of them kill animals so suddenly that no assistance can be given.

Although all these vapors produce similar effects, and occasion sudden and mortal faintings and syncopes, yet some differences may be observed in the properties and modes of acting of these vapors in different places. From which we may presume, that they are not all exactly of the same nature.

Some of them are visible, and appear in form of a fog: such is that which is found in a quarry near to the mineral waters of Pyrmont; and of which Dr. Seip has given a description in the Philosophical Transactions. This vapor has a sulphureous smell, destroys insects, birds, and in general all animals which approach it, with symptoms similar to those which animals suffer when placed under an exhausted receiver of an air-pump.

Others, though perfectly invisible, produce the same effects. Such are, says the learned translator of Lehman, those which issue from a cave in Hungary, situated near Ribard, at the foot of Crapack mountains. These vapors are so fatal that they kill birds, while in their flight they approach too near to the mouth of the cave.

Amongst the noxious mineral exhalations we may also place those which are found in the mines of Sal-gem in Poland. These frequently appear in form of light flocks, threads, and webs, like those of spiders. They are remarkable for their property of suddenly catching fire at the lamps of the miners with a terrible noise and explosion. They instantly kill those whom they touch. This explosion is a true subterranean thunder. Similar vapors are found in some mines of fossil-coal.

As arsenic is the greatest poison of all mineral substances, as it is volatile, and abounds in almost all mines, many authors have supposed that damps contained something arsenical. But this opinion is so far from being proved, that strong reasons induce us to believe that they are of a different nature. We are certain, and I know it from my own experience, that a person may be a considerable time exposed to a large quantity of vapors of arsenic without suffering any of the symptoms occasioned by damps, and even without being much incommoded.

Secondly, the effects produced by arsenic taken internally, even in a large quantity, although terrible, and always fatal, are not nearly so sudden as those occasioned by damps, which instantaneously kill. Thirdly, no observation or experience have ascertained the arsenical nature of any damps; and it is even demonstrable, that many of these noxious mineral vapors are nothing else than volatile sulphureous acid.

Lastly, all those which are not evidently volatile sulphureous acid appear to be pure, or almost pure phlogiston disengaged from bodies without burning. They occasion exactly the same accidents as exhalations of liver of sulphur, of burning coals, and of matters undergoing the putrid or spirituous fermentations. The great inflammability of these vapors, when they are confined, and condensed to a certain degree, such as those of coal-mines, is a demonstrative proof of this opinion.

By art we may perfectly imitate these vapors. We know that when acids dissolve imperfect metals, they take from them a considerable part of their inflammable principle. This principle is almost totally dissipated in vapors during these solutions; and if the operation be made in a close vessel, when this is uncorked, and a lighted candle brought near its mouth, the vapor contained instantly catches fire, and occasions an explosion so much more violent as the quantity of vapor was greater. This phenomenon may be chiefly observed in the solution of iron in vitriolic acid diluted with a certain quantity of water. If after this explosion the bottle be left open, supposing the solution of the metal to be continuing, and the flame of a candle applied to the mouth of the containing vessel; the phlogiston, which is continually disengaging and forming vapors, but freely and without condensation, will continue to burn in such a manner, that a light-bluish flame will be seen at the mouth of the vessel, such as the flame of phlogiston always is when this is not in an oily state.

Although these experiments are generally made by means of a solution of filings of iron in vitriolic acid, I doubt not that, by employing proper management, similar vapors might be produced from other imperfect metals, especially those which most easily part with their phlogiston when dissolved by acids, as tin, zinc, and regulus of antimony; and I doubt not that if these metallic vapors were collected in a sufficient quantity in a close place, where the air was not renewed, that they would produce the same fatal accidents as these called damps.

All these considerations induce us to believe, that most of these noxious subterranean vapors are nothing but phlogiston disengaged from certain substances, and circulating within the earth. It proceeds from bitumens and from sulphur, which undergo different alterations and decompositions.

Almost all chemists and metallurgists agree in believing, that mineral exhalations contribute to the production of metals. This opinion is so much more probable, that, as phlogiston is one of the principles of metals, (if it be true that these mineral exhalations are nothing else than phlogiston) and as this principle is then in state of vapor, and consequently much divided, perhaps reduced to its smallest integrant particles, it is then in its most favorable state for combination: it is therefore probable, that when these exhalations meet earths disposed to receive them, they combine more or less intimately with these earths, according

cording to their nature. Perhaps this is the chief operation of the grand myftery of metallifation. *See* METALS and PHLOGISTON. *(m)*

CCXX. DECANTATION. By this word is meant the feparating of a clear liquor from a fediment, by pouring it gently.

CCXXI. DECOCTION. This word is applied to fignify either the action of boiling a fubftance in water, or the water itfelf in which the fubftance has been boiled.

Decoction is only applicable to matters containing fome principles foluble in water; fuch, particularly, are vegetable and animal matters; and this operation is rather ufed for the purpofes of medicine than of chemiftry.

It is neverthelefs very neceffary to know well the nature and principles of fubftances fubjected to decoction, that it may be properly managed, and that the principles with which the water becomes impregnated may be known.

Thefe principles muft evidently be fuch as are not fufficiently volatile to rife with the heat of boiling water, if the decoction fhall be long continued.

Hence it follows, that plants, or other matters containing volatile principles, cannot be proper fubjects of decoction, when thefe principles are required. In this cafe the matters may be infufed with water in clofe veffels without heat, or with a heat lefs than that of boiling water.

(m) The damps or vapors mentioned in this article are of two kinds, *inflammable* and *uninflammable*. The inflammable kind is probably, as the author believes, fimilar to the vapors produced by the folutions of iron, zinc, tin, and perhaps of other metallic fubftances in vitriolic and marine acids. *See* AIR (FIXABLE). This vapor is chiefly found in coal mines, and fometimes in lead mines, as in thofe of Mendip hills. Like the inflammable vapor of metallic folutions, it is lighter than atmofpherical air, and confequently floats chiefly near the roofs of mines: miners, therefore, when it is accidentally inflamed, or when they purpofely fet fire to it, to deftroy it, lie flat on the ground, and thus efcape burning. This inflammable vapor may perhaps be produced by the decompofition of pyritous matters, with which moft mines, efpecially coal mines, abound. In this decompofition of pyrites expofed to air and moifture, the vitriolic acid of the fulphur attacks and diffolves the iron, while the inflammable principle of the fulphur is difengaged, and forms this vapor.

The *uninflammable vapors* of mines and fubterranean places are much more noxious than the former. They feem to be fimilar to the uninflammable vapors produced by the combuftion of inflammable bodies, as of charcoal, and by fermenting and effervefcing fubftances. *See* AIR (FIXABLE). Like thefe, they are noxious to animals, extinguifh flame, and are heavier than atmofpherical air; for they are chiefly placed at the bottom of the pits in which they are found: accordingly, in the cavern near Pyrmont, mentioned in the text, a man may ftand upright without any other inconvenience than an uncommon heat of his lower extremities, but he cannot without danger keep his head bent down. The fymptoms attending perfons expofed to fuch vapors fhew fufficiently that they are not noxious merely by interception of common air, but by fome quality which almoft inftantly affects and deftroys the powers of animal life. Some perfons digging in a cellar in Paris were found dead, ftiff as ftatues, with open eyes, and ftanding in the pofture of digging. At Chartres, in France, a perfon going down into a cellar into which a baker had been ufed to throw hot embers from his oven, was inftantly killed; and when his body was opened, his lungs were found fpotted with black marks; his inteftines fwoln, red and inflamed; and the mufcles of his legs, thighs, and arms, feemed to be feparated from each other and from the adjacent parts. *See Bomare's Dict. d'Hiftoire Naturelle, at the word* EXHALAISON.

But

But on the contrary, when it is not intended to preserve the volatile parts, or when the matters contain none that are volatile, then decoction may be employed. It even becomes necessary when the matters to be treated are solid, and of a compact and close texture; because then the water could not extract its principles without a boiling heat.

Most soft animal matters, as flesh, tendons, skins, may be boiled conveniently in water; because they contain no principle volatile with a boiling heat. Water extracts from them nothing but a gelatinous substance, and some oily parts which float on the surface of the water.

Decoction is the only method by which all the gelatinous substance of the solid parts of animals, as bones and horns, can be extracted.

All vegetable matters which are inodorous, and particularly those which are hard, as roots, barks, are generally boiled when an extraction of their principles by water is required.

However, many of these substances ought not to be boiled; those particularly, the principles of which, when extracted by water, suffer some change by a continued heat. Peruvian bark, for instance, which is inodorous, and contains nothing volatile, seems capable of being treated without any inconvenience by boiling; nevertheless, Mr. Beaumé observes, in his Elements of Pharmacy, that the infusion of this bark made without heat really contains more of its principles than the decoction. The cause of this is, that water extracts from bark not only the substances of which it is naturally a menstruum, such as the gummy and extractive matters, but also a considerable quantity of resinous substance, which keeps well dissolved in the water by means of the former matters, till it is exposed to heat, and then it immediately separates and precipitates.

Many other vegetable matters exhibit the same phenomenon; therefore a general rule may be established, that decoction ought not to be employed but when absolutely necessary, that is, when the same principles or the same quantities of these principles cannot be obtained by an infusion, and that without heat, if it can be so done, considering that the proximate principles of vegetables are generally so delicate, and so susceptible of change and decomposition, that frequently the most gentle heat changes much their nature and properties. *See* EXTRACTS.

CCXXII. **DECOMPOSITION *of* BODIES.** The chemical decomposition of bodies consists in the disunion and separation of their principles and constituent parts.

This decomposition ought necessarily to be distinguished from a mere mechanical division, as the following reflections will shew.

All bodies in general, or portions of any matter, may be considered as composed of parts separable from each other.

We cannot, for instance, conceive an atom of matter so small, but that this atom may be considered as divisible into parts still smaller; and this undoubtedly has given the idea of the infinite divisibility of matter, a subject which we do not mean to examine here, because it does not belong to chemistry; besides that, it is like all those in which the consideration of infinity is concerned, that is, an absurdity seems to be joined with evidence.

As chemistry is a science solely founded on experience, we shall confine ourselves to what experience teaches concerning the divisibility of bodies.

But

But we are certain that bodies may be very soon reduced to so small parts that we cannot further divide them, from the deficiency of our senses and of our instruments.

One thing is very remarkable in this division, called mechanical, because it is performed by cutting or bruising instruments; this is, that however small the parts be into which it reduces bodies, these parts are always entirely of the same nature as the body from which these parts were taken. These small parts of bodies are called their integrant parts. Thus, for example, the smallest atoms into which iron, salt, resin, or other substance, can be mechanically divided, have all the same properties, excepting quantity, which the mass had before the division.

Hence we ought to conclude, that this mechanical division cannot separate bodies but into homogeneous parts, or parts of the same nature: and if we had no other method of dividing bodies, the compounds would always remain such as nature offers to us, without causing any other change than a diminution of quantity.

The same thing would happen, if all natural bodies were equally simple, or equally compounded. But all chemical experiments shew, that in this respect there is a very great diversity.

Some bodies are so simple that no change can be produced upon them by any effort of art. These are called by chemists elements, or primitive principles. But these simpler bodies, the parts of which are evidently more small and fine than those of bodies less simple, become in the hands of chemists instruments capable of dividing these latter much further than can be done by mechanical instruments. These simple bodies are capable of dividing molecules, which would be still imperceptible by our senses, although they were much larger than they are when they have undergone this invisible division.

To illustrate this by an example. Let us suppose a metallic mass composed of mercury and gold, in such proportion that no mercury can be forced out from the mass by expression, which is a mechanical method. I say then, that the mechanical division which could be made of this compound, would only separate it into smaller and smaller molecules, each of which would be of the same nature as the original mass, that is to say, composed of an equal proportion of mercury and gold.

If indeed we had instruments and senses sufficiently fine, we might at length come to molecules, each of which would be composed of one atom of mercury and gold, which by one division more would be separated into two atoms, one of each of the two metals distinctly. Thus we might obtain the mercury and the gold separately, and consequently effect a decomposition of the compound substance subjected to this mechanical division: but the impossibility of such a division is sufficiently demonstrated.

Yet what mechanical instruments cannot do, fire, which is one of those simple bodies we have mentioned, is capable of performing. The primary parts of this element, much finer than those of gold or of mercury, become in the hands of chemists instruments inconceivably fine, which effect a separation of mercury from gold, consequently reduce to its elements or principles the compound

pound which has been subjected to their action, and thus analyse or chemically decompose it. *See* ANALYSIS.

CCXXIII. DECREPITATION. By decrepitation is meant the quick separation of the parts of a body, occasioned by a strong heat, and accompanied with noise and crackling. This effect is most frequently produced by water contained betwixt the parts of a decrepitating body, when these parts have a certain degree of adhesion together. This water being quickly reduced into vapors by the heat suddenly applied to it, rarefies and bursts with noise the parts which compress it.

The bodies most subject to decrepitation are certain salts, such as *common salt*, *vitriolated tartar*, *nitre of lead*, the decrepitation of all which proceeds from the water of their crystallization, *clays* which are not perfectly dry, and *flints*.

CCXXIV. DELF WARE. This is a kind of pottery of baked earth, covered with an enamel or white glazing, which gives it the appearance and neatness of porcelain.

Some kinds of this enamelled pottery differ much from others, either in their sustaining sudden heat without breaking, or in the beauty and regularity of their forms, of their enamel, and of the painting with which they are ornamented.

In general, the fine and beautiful enamelled potteries, which approach the nearest to porcelain in external appearance, are at the same time those which least resist a brisk fire. Again, those which sustain a sudden heat are coarse, and resemble common pottery.

The basis of this pottery is clay, which is to be mixed when too fat with such a quantity of sand, that the earth shall preserve enough of its ductility to be worked, moulded, and turned easily, and yet that its fatness shall be sufficiently taken from it, that it shall not crack or shrink too much in drying or in baking.

Vessels formed of this earth must be dried very gently to avoid cracking. They are then to be placed in a furnace to receive a slight baking, and which is only meant to give them a certain consistence or hardness. And, lastly, they are to be covered with an enamel or glazing, which is done by pouring upon the vessels thus prepared, the enamel which has been ground very fine and diluted with water.

As vessels on which the enamel is applied are but slightly baked, they readily imbibe the water in which the enamel is suspended, and a layer of this enamel adheres to their surface. These vessels may then be painted with colors composed of metallic calxes mixed and ground with a fusible glass. When they are become perfectly dry, they are to be placed in the furnace included in cases of baked earth, called *seggars*, and exposed to a heat capable of fusing uniformly the enamel which covers them.

This heat given to fuse, the enamel being much stronger than that which was applied at first to give some consistence to the ware, is also the heat necessary to compleat the baking of it. The furnace and the colors used for painting this ware are the same as those employed for porcelain. *See* PORCELAIN.

The glazing, which is nothing but white enamel, ought to be so opake as not to shew the ware under it. Many receipts for making such enamels may be found in Neri's Treatise on the Art of Making Glass, with Kunkel's Notes, and in the Encyclopedia, both which books may be consulted on this subject. We shall

shall only observe in general, that all these enamels for delf-ware are composed of sand or flints, vitrifying salts, calx of lead, and calx of tin; and that the sand must be perfectly vitrified so as to form a glass considerably fusible. Somewhat less than an equal part of alkaline salt, or twice its weight of calx of lead, is requisite to effect such vitrification of sand. The calx of tin is not intended to be vitrified, but to give a white opake color to the mass; and one part of it is to be added to three or four parts of all the other ingredients taken together.

From these general principles, various enamels may be made to suit the different kinds of earths to which they are to be applied.

To make this enamel, lead and tin are calcined together with a strong fire, and the sand is also to be made into a fritt with the salt or ashes. The whole is then to be well mixed and ground together. This matter is then to be placed under the furnace, where it is melted and vitrified during the baking of the ware. Then it is to be ground in a mill, and applied as we have directed. *See* CLAY, POTTERY, PORCELAIN, *and* VITRIFICATION.

CCXXV. DELIQUESCENCE. We understand by deliquescence the property which certain bodies have to attract moisture from the air, and of becoming thereby liquid.

This property is never found but in saline substances, or in matters containing them. It is caused by the great affinity which saline substances have with water. Hence, the more simple these substances are, the more also they are deliquescent. Acids, for instance, and certain alkalis, which are the most simple of saline substances, are also the most deliquescent. Mineral acids are so deliquescent that they strongly imbibe moisture from the air, although they are already mixed with a sufficient quantity of water to be fluid. For this purpose it is sufficient that they only be concentrated to a certain degree.

Many neutral salts are deliquescent, chiefly those whose bases are not saline substances. Their acids are but imperfectly saturated; and although they do not give the same marks of acidity as when quite disengaged, they may be considered as still possessing enough of their activity to exercise it on the moisture of the circumambient air. This proves, that the acids of neutral deliquescent salts are in an intermediate state betwixt that of an acid quite disengaged, and that of one perfectly saturated and combined.

All the phenomena which salts present relatively to their deliquescence, are so many proofs of what we have affirmed on this subject.

Salts formed by vitriolic acid with fixed or volatile alkalis, earths, or metallic substances, are not deliquescent; although this acid be the strongest of all, and which, when disengaged, most powerfully attracts moisture from the air. But its greater strength is the real cause of its forming so complete and intimate combinations with these several substances as to form neutral salts which are not deliquescent.

The nitrous and marine acids form with absorbent earths and certain metallic substances, particularly with iron and copper, deliquescent salts, from the weakness of the union which they contract with these matters. These acids form with silver, mercury, lead, and bismuth, salts which are not deliquescent, because they combine more intimately and completely with these latter metals.

Singular phenomena are preſented by vegetable acids relatively to the deliqueſcence of the neutral ſalts formed by them. The acid of vinegar united with fixed vegetable alkali forms a very deliqueſcent ſalt, called *terra foliata tartari.* The ſame acid forms with copper a ſalt that is not deliqueſcent, as we ſee in the inſtance of *cryſtals of copper.* Theſe effects are directly contrary to thoſe produced by the nitrous and marine acids united with the ſame ſubſtances; for theſe acids form with fixed vegetable alkali ſalts which are not deliqueſcent, and with copper ſalts which are very deliqueſcent.

The acid of tartar, which when diſengaged is in a concrete ſtate, and far from being deliqueſcent, ſince it is ſcarcely ſoluble in water, forms with iron (another ſubſtance ſtill leſs ſoluble) a very deliqueſcent ſoluble tartar, known by the name of *tartariſed tincture of iron.*

Many reſearches and experiments remain yet to be made to explain entirely the cauſes of theſe ſingular effects. But probably the deliqueſcence or oppoſite quality of ſalts will be found to depend on the ſtate of their acids, as we have already ſaid.

The fixed vegetable alkali is deliqueſcent, the mineral is not. The cauſe of this undoubtedly is, that the ſaline principle of this latter is combined more intimately, or with a greater quantity of matter not ſaline, than that of the former, as the other properties of theſe two alkalis indicate. *See* ALKALI.

Fixed vegetable alkali treated with quicklime becomes more deliqueſcent. Volatile alkalis, which are naturally not deliqueſcent, become by treatment with quicklime deliqueſcent. We cannot explain theſe phenomena without ſuppoſing that quicklime takes from alkalis in general a portion of oily or other matter, which binds and ſaturates their ſaline principle, when in their natural ſtate.

The dry extracts of almoſt all vegetable matters eaſily moiſten in the air. But they certainly poſſeſs this property ſo much more evidently, as a greater quantity of earthy or reſinous matter, which is always depoſited during the evaporation, has been previouſly ſeparated from their infuſions and decoctions.

Before we finiſh this article we ought to obſerve, that ſome bodies which are not deliqueſcent attract moiſture from the air, and even become liquid, that is, if they be ſaline or ſoluble in water. This happens when bodies are much colder than the air to which they are expoſed. The reaſon of it is, that the moiſture contained in the air being always in the ſtate of inſenſible vapors, is condenſed by the cold of the bodies it touches, and is collected in drops. This effect is very different from a true deliqueſcence; but it deſerves to be taken notice of, to prevent miſtakes in experiments.

Laſtly, we muſt remark, that ſome bodies, after having been a long time expoſed to the air, may remain apparently dry, although they really be in the diſpoſition of deliqueſcent bodies, that is, attract much moiſture from the ambient air. Such, for inſtance, is quicklime, which imbibes from the air its equal weight of moiſture, and retains, notwithſtanding, its dry and powdery appearance. This proceeds from the great quantity of earthy parts with which thoſe parts of the quicklime are mixed, which may be conſidered as deliqueſcent, although, in fact, they do not reſolve into a liquor.

CCXXVI. DELIQUIUM. This term is frequently employed by chemiſts to characterize a body which is reſolved into a liquor by expoſure to

air.

air. In this ſenſe they ſay the deliquium of a ſalt, as of ſalt of tartar, for inſtance. This word is alſo frequently uſed inſtead of deliqueſcence. Thus we ſay, that a ſalt falls into a deliquium, to ſignify that it is deliqueſcent.

CCXXVII. DEMI-METAL. The ſame as SEMI-METAL; *which ſee.*

CCXXVIII. DEPHLEGMATION. Dephlegmation is an operation by which the ſuperabundant water of a body is taken from it, and it is principally effected by evaporation or diſtillation. Dephlegmation is alſo called concentration, particularly when acids are the ſubject. *See* CONCENTRATION.

CCXXIX. DETONATION. By the word *detonation* chemiſts underſtand an exploſion with noiſe made by the ſudden inflammation of ſome combuſtible body. Such are the exploſions of *gun-powder*, *fulminating gold*, and *fulminating powder*. As nitre is the cauſe of moſt exploſions, the word *detonation* has been appropriated to the inflammation of the acid of this ſalt with bodies containing phlogiſton, and it is frequently given to thoſe inflammations of nitrous acid which are not accompanied with exploſion. Thus nitre is ſaid to detonate with ſulphur, with coals, with metals, although in the ordinary method of making theſe operations, that is, in open crucibles, and with ſmall quantities of detonating ſubſtances, the nitre does not truly explode.

CCXXX. DETONATION of NITRE. The detonation of nitre is one of the moſt important phenomena of chemiſtry. It conſiſts in the inſtantaneous inflammation and decompoſition of the acid of nitre, when it immediately touches combuſtible bodies, the phlogiſton of which is ignited, or when the acid is ignited.

By two methods then may nitre, or rather its acid, be inflamed. The firſt method is by applying it to a red-hot combuſtible body; and the ſecond is by making the acid itſelf red-hot, and applying a combuſtible body to it in that ſtate.

A very neceſſary remark is, that nitre cannot detonate without the concurrence of theſe circumſtances now mentioned. Nitre may be made red-hot, or of any degree of heat, without ſhewing any ſign of inflammation, provided it does not touch any inflammable matter.

On the other ſide, nitre may be heated, and a combuſtible body applied to it without any inflammation. For this purpoſe, the nitre need only be not ſufficiently hot to kindle the inflammable bodies applied to it. Meſſrs. Macquer and Beaumé ſhow, in their Courſe of Chemiſtry, an experiment which clearly proves this truth. Some nitre is put into a crucible, and there completely fuſed by a heat juſt ſufficient for that purpoſe; when a black coal is thrown into this fuſed nitre, no inflammation ariſes, becauſe the nitre may be melted with a degree of heat which is not ſufficient to kindle combuſtible bodies; and this degree of heat is neceſſary for the ſucceſs of the experiment.

But when nitre is red-hot, and a coal is applied to it, kindled, or not kindled, then it is inflamed with violence, and makes the coal burn rapidly. The ſame event happens when nitre is thrown upon burning coals. This inflammation laſts while theſe two ſubſtances touch, and any acid remains in the nitre. During this detonation a conſiderable ſmoke riſes; but this ſmoke contains no acid, as the experiment of the clyſſus of nitre made in cloſe veſſels ſufficiently proves. *See* CLYSSUS *of* NITRE.

When all the nitrous acid is thus burnt, and no longer any inflammation is excited, although more coals are added, if we examine what remains in the crucible, we ſhall find that it is the fixed alkali which was the baſis of the nitre. This alkali is called *fixed* or *alkaliſed nitre*. See *theſe words*, *and* ALKALI (FIXED VEGETABLE).

The detonation may be rendered more eaſy and ſudden by making the nitre touch the inflammable matter in a greater number of parts; ſo that when theſe two ſubſtances are divided into very minute parts, which are well mixed and interpoſed betwixt each other, the detonation is almoſt inſtantaneous, and is as ſtrong as it can be made. When the ſubſtances are thus prepared, they may be at once inflamed by a ſmall ſpark of ignited matter; becauſe the ignition is very quickly and almoſt inſtantaneouſly communicated by ſmall intervals. From the accurate mixture of the two detonating ſubſtances proceeds the great force and violence of *gun-powder*. *See* POWDER (GUN).

Hence we may learn to avoid the violence of detonations in chemical operations, by mixing very imperfectly the nitre with the combuſtible ſubſtances.

Let us now conſider what paſſes in the detonation of nitre. Mr. Macquer, in his Elements of Chemiſtry, conjectures that the detonation of nitre, which is, properly ſpeaking, the inflammation of the nitrous acid, cannot take place, unleſs a combination be previouſly formed betwixt this acid and the phlogiſton of the combuſtible ſubſtance uſed for the detonation; that this combination is entirely ſimilar to that of vitriolic acid with phlogiſton when ſulphur is formed; and that, in the preſent inſtance, *a nitrous ſulphur* is produced; but that this ſulphur is infinitely more combuſtible than the vitriolic ſulphur, for a reaſon we ſhall ſoon ſee, and even ſo combuſtible, that it cannot exiſt an inſtant without being entirely burnt; hence it is inflamed with extreme rapidity and violence as ſoon as it is formed.

The moſt eſſential circumſtances attending the detonation of nitre concur in rendering this opinion probable, that is, to eſtabliſh the preliminary exiſtence of this nitrous ſulphur.

Firſt, vitriolic ſulphur cannot be formed by vitriolic acid engaged with a fixed alkali, unleſs this acid be deprived of all the water ſuperabundant to its ſaline eſſence, and in a dry ſtate, when it is applied to phlogiſton.

In the ſecond place, to effect this combination, a degree of heat equal to that of ignition muſt be applied.

Thirdly, as in ſulphur not a particle of oil exiſts, but the vitriolic acid is united to pure phlogiſton, as the illuſtrious Stahl has fully demonſtrated; if, therefore, an inflammable matter, which is in an oily ſtate, be uſed for the formation of ſulphur, it muſt be firſt decompoſed, and reduced to the ſtate of coal, before the ſulphur can be produced. *See* SULPHUR. But theſe are preciſely the ſame conditions which are neceſſary for the detonation of nitre; for ſince the acid of nitre cannot detonate unleſs it be ignited, it muſt be evidently deprived of all the water ſuperabundant to its ſaline eſſence.

In the ſecond place, experience ſhews that nitre cannot detonate with any matter which is in an oily ſtate; for if nitre be ignited in a crucible, and oil, reſin, fat, or other inflammable matter of this kind be added to it, no detonation will happen while the inflammable matter remains in its oily ſtate, or till it be burnt, decompoſed, and reduced to a coal; then the detonation commences, and

and is always proportionable to the quantity of coal produced by the inflammable matter.

Some ſubſtances, the phlogiſton of which is certainly in an oily ſtate, ſuch as tartar, ſaw-duſt of wood, and others of this kind, do indeed detonate with nitre almoſt as readily as powder of charcoal; but we may eaſily perceive that the cauſe of this is, that the oil of theſe ſubſtances, being divided by the interpoſition of a large quantity of incombuſtible matters, may be exceedingly ſoon reduced to the ſtate of coal by the heat of ignition.

Several facts intimately connected with the detonation of nitre may be naturally deduced from this theory, and conſequently become additional proofs of it.

Let nitrous acid, as much dephlegmated as poſſible, be poured upon black coals, as dry and hot as they can be made, under a red-heat, no detonation or inflammation will enſue. This is not ſurpriſing, ſince all the neceſſary conditions for the production of nitrous ſulphur are wanting here, and ſince in ſimilar circumſtances ſulphur could not be formed by vitriolic acid.

If an ardent coal be plunged into the ſtrongeſt nitrous acid, a detonation begins at the ſurface of the coal, which very ſoon ceaſes; the coal is extinguiſhed, becomes black, and is not affected by the acid. The ſhort detonation upon the ſurface of the coal may be conſidered as accidental, and not belonging to the experiment; otherwiſe the detonation would continue while the acid laſted. This detonation can only be cauſed by a ſmall quantity of nitre, formed inſtantaneouſly by the acid uniting with ſome ſmall portion of alkaline ſalt contained in the aſhes of the coal, which happen to lie on its ſurface: therefore, when this ſmall quantity of nitre is conſumed, the coal is extinguiſhed, and the detonation ceaſes; and all this ought to happen becauſe the moſt dephlegmated nitrous acid contains always a conſiderable quantity of water ſuperabundant to its ſaline eſſence; and as it is not in the preſent experiment retained or fixed by any baſis, it diſſipates in vapors before it can be totally dephlegmated by the heat of the ardent coal: hence in this experiment no nitrous ſulphur can be formed; neither can vitriolic acid form vitriolic ſulphur in ſimilar circumſtances, but only volatile ſulphureous acid.

From theſe facts we may conclude, that nitrous acid, while free, that is, not engaged in any baſis, cannot ever contract with phlogiſton ſuch an union, as that a ſulphureous compound, or nitrous ſulphur, ſhall be formed; not only becauſe of the ſuperabundant water it always contains, but alſo becauſe, from its want of fixity, it cannot be deprived of this ſuperabundant water in the very act of combination. We may therefore affirm as a general and eſtabliſhed principle, that diſengaged nitrous acid is not capable of detonation. If then this pure acid inflames oils mixed with it, this inflammation proceeds from a very different cauſe than the true detonation of nitre, as Mr. Macquer has ſhewn in his Elements of Chemiſtry; nitre and diſengaged nitrous acid being very different from each other, particularly with regard to detonation. *See* INFLAMMATION *of* OILS.

What we have ſaid on this ſubject clearly ſhews why combinations of nitrous acid with certain baſes form nitres ſuſceptible of a ſtrong detonation, while others of the ſame acid with different baſes detonate weakly or not at all; theſe differences depending on the greater or leſs adheſion of the nitrous acid with its baſis. All thoſe

nitrous

nitrous salts in which the acid is so firmly fixed and retained by its basis, that it may be entirely dephlegmated and ignited, are susceptible of a strong detonation; such are *ordinary nitre, cubic nitre, nitrous ammoniacal salt, nitres of silver, of mercury, of lead, and of bismuth*; of all which ordinary nitre detonates most violently, and is the only one of which good gun-powder can be made; because the fixed vegetable alkali, which is the basis of nitre, has a stronger adhesion to nitrous acid than any other of the substances soluble by this acid.

On the contrary, all combinations in which nitrous acid is only weakly united, do not detonate, or very weakly. Such are *nitres with basis of calcareous earths, of copper, of iron, of tin, of regulus of antimony*; these being all nitrous salts in which the acid adheres weakly; as their deliquescent quality, and the facility with which fire detaches this acid from them, sufficiently show.

We shall now examine what happens in the very act of the detonation of nitre, or rather in the deflagration of nitrous sulphur. We have seen that this sulphur is formed in the same circumstances as vitriolic sulphur: but if these two compounds resemble each other in the manner of their production, they differ entirely in the phenomena of their combustion.

Vitriolic sulphur burns very weakly; produces a flame which is very little luminous; requires for the continuance of its burning a constant supply of new air; and its acid undergoes no change by this combustion. Nitrous sulphur, on the contrary, appears incapable of existing an instant without burning. Its vivid, dazzling flame, accompanied with noise, resembles the flame of a fire strongly actuated by a blast of air; it needs not the contact of external air; it burns with the same violence and rapidity in close vessels; no obstacle is capable of containing it; and if it be confined, it bursts with a terrible noise the sides of the confining vessels; lastly, after its combustion no trace is found of its acid.

What can be the cause of so considerable differences? and how are so singular phenomena produced? We cannot do better than adopt entirely the theory of Stahl. This great chemist has explained all these effects in a manner the most satisfactory, and the most conformable to the principles of rational chemistry.

Stahl considers nitrous acid as composed of a watery principle, and of an earthy principle, as well as all other acids: but he also admits a third element to enter into this acid, by which it is characterised, and by which it differs from vitriolic acid. This third principle of nitrous acid is phlogiston; but this principle is so proportioned and combined with the other two, that nitrous acid is not inflammable while alone, even when it is ignited: but if a new quantity of inflammable principle unites with nitrous acid, (which happens in the production of nitrous sulphur) then the proportion of this principle being increased, it accordingly assumes all the properties, and particularly the inflammability, which is essential to it. Hence nitrous acid cannot be combined with a body containing phlogiston, so disposed as to be capable of forming with it an intimate union; that is, a nitrous sulphur, without producing an inflammation. If, then, phlogiston united intimately with vitriolic acid forms vitriolic sulphur, which is much less inflammable, this happens because phlogiston is not one of the principles of vitriolic acid, and does not enter into its combination, as it enters into that of nitrous acid.

From this cause also, namely the existence of phlogiston in nitrous acid, as a principle, Stahl deduces the destruction or total decomposition of this acid,

when it is inflamed, and this he does upon good grounds; for then not only the phlogiston which is combined superabundantly with nitrous acid is inflamed, but also this superabundant phlogiston, finding itself mixed and confused with the phlogiston which is a principle of nitrous acid, takes this along with it in its inflammation, and the whole is entirely consumed.

This being established, we ought not to wonder that no nitrous acid is found after the detonation; for every compound body, from which one of its principles is taken, is thereby necessarily decompounded. If the inflammable principle of this acid could be consumed without destroying the connexion of the other principles, we should not indeed find after detonation any nitrous acid, because the phlogiston, its distinguishing principle, would have been taken from it; but as, according to Stahl, the union of the two principles, the watery and the earthy, is sufficient to constitute an acid, we should still find an acid substance of a different nature from nitrous acid, nearly in the same manner that we find pure vitriolic acid after the portion of phlogiston which had constituted it volatile sulphureous acid has been taken from it: but things pass quite otherwise in the inflammation of nitrous acid; not a vestige remains of this, or of any other acid; nothing is found again but earth and water. This shews the connexion of the principles of nitrous acid to be such, that one of its constituent parts cannot be taken from it without an entire disjunction of the others; so that after its inflammation, it does not exist neither as nitrous, nor as any other acid.

We may easily perceive how much these facts, and the consequences resulting from them, give probability to the opinion of Stahl, who thinks that every acid, in general, results from an union of a watery with an earthy principle; and that the particular and specific properties of the several acids are caused by some other principle, which enters into their combination with these two essential constituent parts.

The explosion accompanying the detonation of nitre, and which is so much more violent as the matters have been more perfectly mixed, and more closely compacted, proceeds from a great and sudden dilatation of some very expansible body. Most natural philosophers have attributed it to air contained in nitre, and in matters with which the nitre detonates; because air included and rarefied is capable of producing, and does produce, very violent explosions: nevertheless, we must observe, that none of the explosions of air are equal in violence to those of gun-powder, of fulminating-powder, and of fulminating-gold, which are certainly effects of the inflammation of nitrous acid.

These considerations also incline us to adopt the opinion of Stahl on this phenomenon. This chemist thinks, that these explosions ought not to be attributed to the air, but to the water of the nitre, or rather of its acid; which is capable of producing much more violent explosions than those of air, when a strong heat, such as that of red-heat, is suddenly applied to it, as happens in the detonation of nitre. See WATER.

The same chemist goes farther. He advances, not without much probability, that water, the aggregation of which is entirely broken, acquires the property of air. Upon this supposition we may well explain why nitre is capable of burning with combustible substances, without the access of air, and in close vessels. The reason of this is, that it contains in its own substance a matter which disengages itself from it while it burns, and which, if it is not air, has as well

well, or better, the property of maintaining combustion. The name issuing from nitre when made to detonate so slowly that it can be observed, seems to prove what we have advanced on the subject; for it has, as we have said, all the appearance of the flame of a body excited strongly by a blast issuing from its own centre. (*n*)

Nitre detonates with sulphur, and with those metallic substances the phlogiston of which is so disposed that it can easily burn; such are iron, tin, zinc, and others of this nature. This detonation has nothing peculiar: it must happen not only from the combustibility of the phlogiston of these substances, but also because this phlogiston is not in the state of oil. What we have said concerning the detonation of nitre by coals, is applicable to those which are now treated. However, attention must be given to the other principles of these substances, and to the greater or less quantity, and degrees of combustibility of their phlogiston.

CCXXXI. D E W. Formerly this name was given to the phlegm that rose first in the distillation of several substances. Thus the *dew of vitriol*, *the dew of honey*, were watery liquors which rose first when these substances were distilled.

CCXXXII. D I A M O N D. Diamonds are stones of the vitrifiable kind, which are found naturally crystallized, nearly as rock-crystal is, in form of six-sided prisms, each extremity of which is terminated by a pyramid also of six sides. Some diamonds, however, are differently crystallized.

Diamonds are the most beautiful and the dearest of all precious stones. They are of different colors, particularly yellow; but the greatest part of them are white, and amongst these, the whitest and most transparent are of highest value. No stone is harder than the diamond; it is also very refractory, and even apyrous; it has all the properties of vitrifiable stones, with this difference, that it requires more fire, and a larger quantity of flux to produce its vitrification than any other of the substances of the same kind. *See* STONES (VITRIFIABLE). (*o*)

(*n*) The explosion of nitre deflagrated with inflammable substances is caused by an elastic fluid, which is produced from the nitre and these substances by deflagration. This fluid is not the water of the nitre rarefied and converted into air; for the water of the nitre is only rarefied by the heat of the deflagration, and is afterwards by cold condensed, forming the water called clyssus of nitre. *See* CLYSSUS *of* NITRE. But the elastic fluid produced by deflagration is permanent, and not condensible into a liquid. Mr. Robins found, by accurate experiments, that the fluid produced by firing gun-powder, when confined within a space equal to that of the gun-powder which was fired, and reduced to the heat of the atmosphere, was capable of sustaining a pressure equal to 244 times the pressure of the atmosphere; and that the elastic force of the fluid was increased probably about four times by the heat produced by the firing of the powder; and consequently that it is thereby rendered capable, at the instant of explosion, of sustaining a pressure nearly equal to a thousand times the pressure of the atmosphere. *See* Robins's *Principles of Gunnery*.

(*o*) Diamonds are the most hard, heavy, transparent, and brilliant of all stones. They are either hexagonal prisms terminated by eight-sided points or pyramids; or they are flat, or cubical, or rounded. Whether this difference of form be original, or adventitious, has not been determined. The first kind are the best and hardest, and may therefore have preserved their original form against accidents better than the others, especially than those which are rounded, which are said to be the least hard, and consequently most liable to have their forms altered by attrition

CCXXXIII. DIAPHORETIC ANTIMONY. This is a white calx of antimony, made by calcining antimony with thrice its quantity of nitre. *See* ANTIMONY.

CCXXXIV. DIGESTION. Digestion is an operation which consists in exposing bodies to a gentle heat, in proper vessels, and during a certain time.

This operation is very useful to favor the action of certain substances upon each other; as, for example, of well calcined, dry fixed alkali upon rectified spirit of wine. When these two substances are digested together in a matrass, with a gentle sand-bath heat, the spirit of wine acquires a yellow-reddish color, and an alkaline quality. It is then called *alkaline tincture*, or *tincture of salt of tartar*. *See* TINCTURE *of* SALT *of* TARTAR. The spirit would not so well acquire these qualities by a stronger and shorter heat.

attrition. Diamonds are said to consist of laminæ or plates, and probably they have some uniform texture; because lapidaries find that they may be polished much more easily in one than in any other direction. This stone becomes luminous in the dark by exposure during a certain time to the rays of the sun; by heating it in a crucible; by plunging it in boiling water; or by rubbing it with a piece of glass. By friction it acquires an electrical property, by which it attracts the substance used for foils, called black mastic, and other light matters. The author of the Dictionary says, that diamonds are refractory in the fire, and even apyrous. Nevertheless, experiments have been made, which prove that diamonds are capable of being dissipated not only by the collected heat of the sun, but also by the heat of a furnace. A diamond, by exposure to a concave speculum, the diameter of which was forty inches, was reduced to an eighth part of its weight. See *Phil. Trans.* No. 386. In the *Giornale de Letterati d'Italia*, *Tom.* viii. *Art.* 9. we may read a relation of experiments made on precious stones, by order of the Grand Duke of Tuscany, with a burning lens, the diameter of which was two thirds of a Florentine ell, near the focus of which was placed another smaller lens. By these experiments we find that diamonds were more altered by solar heat than most of the other precious stones, although not the least appearance of a commencing fusion was observable. A diamond weighing thirty grains, thus exposed during thirty seconds, lost its color, lustre, and transparency, and became of an opake white. In five minutes, bubbles appeared on its surface; soon afterwards it burst into pieces, which were dissipated; and the small fragment which remained was capable of being crushed into fine powder by the pressure of the blade of a knife. Neither the addition of glass, flints, sulphur, metals, or salt of tartar prevented this dissipation of diamonds, or occasioned any degree of fusion. By this heat, rubies were softened, and lost some of their color, but preserved their form and weight. By addition of a third lens, a further degree of fusion was given to rubies. Even then rubies could not be made to unite with glass. By having been exposed to this heat, the surface of the rubies which had suffered fusion, lost much of their original hardness, and were nearly as soft as crystal. But their internal parts, which had not been fused, retained their hardness. Emeralds by this heat were rendered white, or of various colors, and soon afterwards were fused. They were found to have lost part of their weight, and to be rendered less hard and brittle.

Experiments were also made by order of the Emperor Francis I. on precious stones, from which we find, that diamonds were entirely dissipated by having been exposed in crucibles to a violent fire of a furnace during twenty-four hours; while rubies by the same heat were not altered in weight, color, or polish. By exposing diamonds during two hours only at a time, the alterations produced on them by fire were observed. First, they lost their polish, then they were split into thin plates, and, lastly, totally dissipated. By the same fire, emeralds were fused. See *Magasin de Hambourg*, *tom.* xviii.

Digeſtion is alſo uſed to ſoften and open certain bodies deſigned to undergo furthe operations, or to excite in them a certain degree of fermentation.

CCXXXV. DISTILLATION. Diſtillation is an operation by which the fluid and volatile principles of bodies may be ſeparated and collected with a convenient degree of heat.

If compounds containing volatile and fixed principles be expoſed to fire, the former being rarefied by heat will endeavor to ſeparate themſelves from the latter; and if the effort which they make for this purpoſe be ſuperior to the coheſion which they have with the fixed principles, a ſeparation will happen, and they will be diſſipated in ſtate of vapor.

The different fixity and volatility, which the ſeveral principles of almoſt every compound body have, furniſhes a very extenſive method of ſeparating and obtaining their principles. This chemiſts effect by diſtillation.

Diſtillation requires an apparatus of veſſels ſuited to the nature of the ſubſtances to be treated, and of the principles to be obtained.

If the ſubſtance to be diſtilled be very compound, very ſuſceptible of alteration by heat, and containing very volatile principles, ſuch as moſt odoriferous plants, ſpirituous liquors, and others of this nature, a veſſel muſt be uſed called an *alembic*, which muſt alſo be provided with a water-bath. *See* Alembic.

As in the diſtillation made with an alembic the vapors riſe vertically, and are condenſed in the upper part of the veſſel called its *capital* or *head*, this method of diſtillation has been called *per aſcenſum*. By this method may be diſtilled all matters volatile enough to riſe with a degree of heat not exceeding that of boiling water: ſuch are the *ſpiritus rector of plants*, *ardent ſpirits*, and all *eſſential oils*.

When compound bodies are to be diſtilled, the moſt volatile parts of which require a heat ſuperior to that of boiling water, *retorts* muſt be employed; becauſe theſe veſſels may be conveniently placed either in a ſand-bath or in a naked fire, and may be ſo diſpoſed in a reverberatory furnace, that the matter which it contains ſhall be equally heated on all ſides.

The ſhape of a retort is ſuch, that principles reduced to the ſtate of vapor cannot iſſue but laterally through the neck of the veſſel, which is accordingly placed on one of its ſides. This diſtillation has thence been called *per latus*. *See* Retort.

This ſecond method of diſtilling is very uſeful, and may be applied to obtain eſſential oils, heavy acids, eſpecially mineral acids, and ſometimes even very volatile ſubſtances; as for example, the volatile alkali from ſal ammoniac, or from animal matters which have not undergone putrefaction.

A third kind of diſtillation is called *per deſcenſum*; becauſe it conſiſts in applying the heat above the bodies whence the volatile parts are to be extricated; and by this method theſe volatile parts are obliged to deſcend into a veſſel prepared for their reception. But this method of diſtillation has many faults, is abſolutely unneceſſary, and is entirely neglected.

We may eaſily conceive what paſſes in diſtillation. Volatile ſubſtances are rendered by a ſuitable heat ſpecifically lighter, are reduced to the ſtate of vapor, and would be diſſipated, if they were not retained, and obliged to paſs into

colder

colder places, where they are condensed and become liquors, if such be their nature; or else they collect in small solid particles called *flowers*, and in this case the operation changes its name, and is called *sublimation*. *See* SUBLIMATION.

As distillation is always performed in close vessels, the matters which rise are excluded from the access of air, which accelerates the ascent of volatile bodies. *See* AIR.

Hence distillations and sublimations, which are, properly speaking, only evaporations in close vessels, are more disadvantageous than evaporations in open air. This is an inconvenience in all cases where distillation may be carried on very fast without any accident. Such, for instance, is the distillation of water alone. This inconvenience may be in a great measure remedied by introducing into the cucurbit a current of air by means of a ventilator, according to a method proposed by an English chemist to accelerate the distillation of sea-water, with a design to obtain by that means fresh water from it.

But in distillations of almost all other substances, this slowness occasioned by want of air is rather useful than disadvantageous; because the more slowly a volatile substance is separated from a fixed substance, the more perfect is the separation. For this reason, when a distillation is required to be performed according to the rules of the art, it must be so conducted that no more heat shall be applied to raise the volatile body than is necessary. This management is particularly necessary when there is not a great difference betwixt the volatility of the principles of the body distilled. We have an evident example of this in all concrete oily matters. When we intend to separate the acid and the oil of which these matters consist, as these two principles have nearly the same volatility, they rise together, and are not disunited; so that the compound body passes in distillation without suffering any decomposition. *See* BUTTER. Notwithstanding the most careful management of most distillations, the volatile principles are seldom obtained perfectly free from the other principles of the compound; and therefore, to be purified, must be submitted to new distillations, called *rectifications*.

We may then establish, as general and essential rules of distillation, that no greater heat ought to be applied than is just necessary to raise the substances to be distilled; and that the slowness of the operation is no less advantageous than the hurrying of it too much is prejudicial.

These rules ought also to be observed for some other very strong reasons. Such is the prevention of the breaking of vessels, which frequently happens in those of glass or of earthen ware when they are too suddenly or too strongly heated, and most certainly happens when the vapors rise more quickly than they can be condensed.

These accidents are chiefly occasioned by vapors which are very elastic and not easily condensible. Some vapors, as these of the smoking nitrous and marine acids, have these qualities so strongly, that much of them is lost, by the necessity of giving frequently a vent to them, by unstopping a small hole made in the balloon employed as a receiver in such distillations, and which might be conveniently made in all receivers*.

* *See* PLATES; where the vessels used in distillations are represented.

CCXXXVI. DITTANY *of* CRETE. *(p)*

CCXXXVII. DIVISION. By *division* we ought to understand that separation which is occasioned in the parts of a body by help of mechanical instruments.

The mechanical division of bodies does indeed separate them into smaller, homogeneous, similar parts; but this separation cannot extend to the primary integrant molecules of any body, and consequently is incapable of breaking what is properly called their aggregation: also, no union is formed betwixt the divided and dividing bodies, in which respect division essentially differs from *solution*.

Division is not properly a chemical operation. It is only employed preparatorily to facilitate other operations, and particularly solution. For this purpose it is very useful, as it encreases the quantity of surface, and consequently the points of contact of any body.

Different methods are used to divide bodies according to their nature. Those which are tenacious and elastic, as horns and gums, require to be cut, rasped, or filed. Metals, because of their ductility, require the same treatment: but as they also are fusible, they may be quickly and conveniently reduced into grains small enough for most operations, by pouring them, when melted, into water.

All brittle bodies may be reduced conveniently into fine parts by being bruised in a mortar with a pestle.

Very hard bodies, such as glass, crystals, stones, particularly those of the vitrifiable kind, before they are pounded, ought to be plunged when red-hot into water, by which they are split and cracked, and rendered more easily pulverable.

Bodies of this kind may also be bruised or ground by means of a hard and flat stone, upon which the matter is to be put, and bruised by another hard stone, so small as to be held and moved upon the larger stone with the hand. The larger stone is called a *porphyry*, from its being generally of that kind of stone; and the operation is called *porphyrisation*. Instead of porphyrisation, a mill may be used, composed of a hard grit millstone, moving round upon another stone of the same kind, which must be fixed: in the upper stone is a groove, or channel, through which the matter to be ground passes. By this method a substance may be more quickly reduced to a fine powder than by porphyrisation. But these mills can be only employed for considerable quantities of matter, as for manufactories of pottery and porcelain.

These methods of mechanically dividing bodies are attended with some practical inconveniences; the most considerable of which is, that some parts of the dividing instruments are always struck off, and mixed with the matter to be di-

(p) DITTANY *of* CRETE. Sixteen ounces of the leaves of this plant yield about half a dram of a strong, aromatic, essential oil, which coagulates by cold, resembling camphor. From an ounce of this plant Neuman obtained with water two drams and a scruple of extract; and from the same quantity, with spirit of wine, he obtained a dram and a half of resinous extract. He observes, that the green color of the leaves resides in the resin, and is extractable by spirit, especially after water has previously extracted the gummy part, some of which being also soluble by spirit along with the resin, alters the color of the spirituous tincture.

vided. This may greatly affect the operations. For instance, instruments of iron and copper furnish coloring metallic parts, and the latter metal is hurtful to health. Porphyry is colored by a reddish-brown matter, which injures the color of crystal-glasses, enamels, and porcelain, made with matters ground upon this stone. These matters, therefore, must be cleansed after their porphyrisation, or else no instruments ought to be employed capable of injuring the intended operations. Thus, for the preparation of all medicines to be taken internally, no copper instruments, as mortars, pestles, ought to be used; those made of iron are preferable; and, instead of porphyries, mortars, grinding-stones, and mill-stones, made of hard and white stones, ought to be employed for substances which are to enter into the composition of enamels, crystal-glass, and porcelain, the whiteness of which is a most necessary quality.

CCXXXVIII. DOCIMASTIC ART. This name is given to the art of essaying, by operations in small, the nature and quantity of metallic or other matters, which may be obtained from mineral or other compound bodies. The most important operations of the docimastic art are found under the words, REFINING, ORES, ESSAYS *of* ORES.

CCXXXIX. DOME. The upper piece of furnaces, and particularly of portable furnaces, is called the *dome*. It has the form of a hollow semisphere or small dome. Its use is to form a space in the upper part of the furnace, the air of which is continually expelled by the fire; hence the current of air is considerably encreased, which is obliged to enter by the ash-hole, to pass through the fire, to supply the place of the air driven from the dome. The form of this piece renders it proper to reflect or reverberate a part of the flame upon the matters which are in the furnace, which has occasioned this kind of furnace to be called a *reverberatory furnace*. *See* FURNACE.

CCXL. DORONICUM. (*q*)

CCXLI. DRAGON'S BLOOD. (*r*)

CCXLII. DUCTILITY. Ductility is a property possessed by certain solid bodies, which consists in their yielding to percussion, pressure, and in receiving different forms, without breaking.

This property is nothing else than a continued adhesion of the integrant parts of those bodies which have this property, although these parts change place respectively to each other. A body, therefore, cannot be ductile, excepting its integrant parts be so disposed, that, while some of its contiguous parts are forced to separate, others apply themselves, so that the whole shall be still one continued substance.

(*q*) DORONICUM. From two ounces of the dry root were obtained by water fourteen drams of extract; and from the same quantity, with spirit, four drams and a half. This root is supposed by some to be poisonous, especially when fresh. *Newman*.

(*r*) DRAGON'S BLOOD is a red colored, inodorous, and insipid resin, unsoluble in water, soluble in spirit of wine and in oils, to both which liquors it communicates a red color. By fire it is fusible, inflammable, and it emits an acid vapor like that of benzoin. A solution of dragon's blood in spirit of wine is used for staining marble, to which it gives a red tinge, which penetrates more or less deeply according to the heat of the marble during application. But as it spreads at the same time that it sinks deep; for fine designs, the marble should be cold. Mr. Du Fay says, that by adding pitch to this solution, the color may be rendered deeper.

The figure of the integrant parts of ductile bodies contributes also probably to their ductility: but as we have not any certain knowledge of the form of the integrant parts of any body, we cannot explain ductility more precisely and particularly.

Some bodies are ductile both when they are hot and when they are cold, and in all circumstances. Such are metals, and particularly gold and silver. Other bodies are ductile only when they have a certain degree of heat; such as wax, and substances of the same kind, and glass *(s)*. The degrees of heat requisite to render these bodies ductile vary according to their different natures. In general, the heat must be such as to be in a middle state betwixt solidity and perfect fusion or fluidity. As wax, for instance, is fusible with a very small heat, it may be rendered ductile by a still smaller heat; and glass, which requires a most violent heat to be perfectly fused, cannot acquire its greatest ductility without being made red-hot and almost ready to fuse. Lastly, some bodies are rendered ductile by the interposition of the parts of a fluid. Such are certain earths, and particularly clays. When these earths have absorbed a sufficient quantity of water to bring them into a middle state betwixt liquidity and solidity, that is, to the consistence of a considerably firm paste, they have then acquired their greatest ductility. Water has precisely the same effect upon them in this respect as fire has upon the other bodies mentioned.

CCXLIII. DULCIFICATION. When caustic and corrosive bodies are rendered milder by being combined with another substance, they are said to be *dulcified*. This term is most commonly applied to the effect produced upon mineral acids by their union with spirit of wine. *See* SPIRITS *of* NITRE, *of* SALT, *and of* VITRIOL (DULCIFIED).

CCXLIV. DYING. The art of dying consists in extracting from various substances coloring particles, and applying them to stuffs or other matters intended to be dyed, so that they shall adhere as firmly and durably as possible. *(t)*

(s) Lastly, other bodies, as some kinds of iron, namely, those called by workmen *red-short*, brass, and some other metallic allays, are ductile only when cold, and are brittle when hot. Concerning the ductility of metals, *see* METALS.

(t) DYING. Notwithstanding the labors of Messrs. Hellot, Astruc, Du Fay, Jussieu, and of some other authors, by which many processes for dying are ascertained; and notwithstanding the attempts of Mr. Hellot to explain these processes, yet the theory of dying is far from being known or established. We do not sufficiently understand the nature of the colorific particles of dying substances; nor the action of the salts and other matters used in most of the processes for durable dyes; nor the causes of the differences of the several stuffs made of wool, silk, cotton, or thread, with regard to their aptitude to receive certain dyes. Many experiments are required to elucidate these subjects.

Before we mention Mr. Hellot's Theory of Dying, we must observe, that dyers enumerate five colors which they call primary, from the mixtures of which the other colors are produced. These are blue, red, yellow, nut-color, and black. *Good dyes* are those which can resist the action of water, air, and of certain saline and saponaceous liquors which are used as proofs of the durability of colors. *False dyes* are those which cannot resist these proofs. We may easily conceive the action of false dyes; that a colored decoction should color any stuff dipped into it by the adhesion of part of it to the stuff; and that when the stuff has become dry by the evaporation of the water of the decoction, it may again be deprived by washing with water of the coloring substance; which being

soluble,

Although the principles of all the mechanical arts have a finglar dependance on chemiftry, as we have endeavoured to fhew in many parts of this work, few of them are fo intimately related to this fcience as the art of dying, all the operations of which are fo many chemical operations. Thefe operations muft be defcribed at full length to fhew all their relations to chemiftry; but thefe de-

foluble, as it was originally, in water, may eafily be wafhed out of the dyed ftuff: but the action of thofe dyes which, although once diffolved or fufpended in water, cannot again, after they are applied to ftuffs, be wafhed out, is not fo eafily underftood. We fhall here treat only of this latter fort, or good and durable dyes. Dyes of different colors require different treatment. Stuffs to be dyed of a *red* or *yellow* color muft be boiled in water with alum and tartar before they are dipped into the dying decoctions: the red coloring materials are *kermes*, *cochineal*, *gum-lac*, and *madder*; the yellow materials are *luteola*, or *dyers weed*, and other *yellow flowers*. The ftuffs for *blue* dyes require no previous preparation. Thefe blue dyes are made of *indigo*, or the blue fecula obtained from *woad* (*fee* INDIGO and WOAD), diffolved in a lixivium of fixed alkali, or in urine, with or without the addition of fome green vitriol. The ftuffs intended to receive a *root color* require no previous preparation but to be foaked in warm water. Thefe dyes are chiefly decoctions of *wallnut fhells*, *wallnut-roots*, *alder-bark*, *fumach*, and *faunders*. To thefe no faline or other matter is added. The *black* dyes, which are *inks*, or decoctions of *galls*, mixed with *green vitriol*, require no previous preparation of the ftuff.

Mr. Hellot's Theory of Dying is, that the coloring particles are fixed into the pores of ftuffs chiefly by means of a vitriolated tartar, which he believes to exift in each procefs, to be produced by the acid of alum and alkaline bafis of tartar in the procefs for red and yellow dyes, to exift originally in the pot-afh employed in the blue dye, and in the nuts and roots employed in the root-colored dye. He fuppofes that the pores of the ftuff are cleanfed and enlarged by the preparatory falts, and by the boiling water, fo as to receive the coloring particles, which particles are afterwards detained by the contraction of the pores occafioned by cold; and further, that thefe pores are lined with a faline cruft of vitriolated tartar, or of tartar; which falts being difficultly foluble in water, retain firmly the coloring particles. But this theory cannot be admitted, when we confider, that vitriolated tartar does not exift in any of the materials ufed in fome of the proceffes for dying, as in the root-color materials, from which no vitriolated tartar can be obtained, unlefs accidentally, till they have been by burning reduced to afhes, and even then the quantity is exceedingly fmall; that although common pot-afh generally contains fome vitriolated tartar, yet Mr. Hellot has not fhewn that pure fixed alkali is incapable of producing the fame effect; and laftly, that vitriolated tartar and tartar, although they require much water to be diffolved, are yet foluble by water; and therefore if the coloring particles were fixed chiefly by means of thefe falts, they might be wafhed out by a large quantity of water; which we find to be contrary to experience.

We fhall find it more difficult to fubftitute a true theory, than to refute that of Mr. Hellot. Many experiments ought to be previoufly made. Neverthelefs we fhall obferve, that the colorific particles ufed in dying feem to be unfoluble in water, in fpirit of wine, and even in alkaline lixiviums; that their diffufion through thefe liquids is caufed merely by their adhefion to certain gummy and refinous particles; and that they may be difengaged from thofe gummy and refinous matters, by applying a piece of ftuff, to which they have a greater adhefive power, which feems to be the cafe of the root-colored and blue dyes; or by applying another fubftance, to which they have a greater power of adhefion, fuch as the earth of alum, in thofe dyes where that falt is ufed together with fome fubftance, as fixed or volatile alkali, capable of decompofing alum; or as the ferrugineous earth of the green vitriol in black dyes, to which the colorific particles of the galls adhere; which earths are capable of applying themfelves, and of adhering to the ftuffs. The feparation of the coloring particles from the gummy and refinous matters is probably facilitated by the addition of acid and

tails would lead us too far from our object. We must confine ourselves to shew the most general principles of dying. These have been already explained in a preliminary discourse to the *Art of Dying Silk*, which is one of the dissertations upon the arts published by the Royal Academy of Sciences. We shall here only make an extract of what is said there, to oblige those readers who have not that collection.

Most vegetable and many animal substances contain coloring principles which may be extracted and applied to other bodies: but these coloring principles are not always nearly of the same nature, and in the same state; and these differences require that different methods should be employed for the extraction and application of them.

Some of these coloring particles reside partly in a saponaceous extractive substance, and partly in an earthy and resinous matter. When substances, the colorific particles of which are in this state, are boiled in water, they impregnate the water with their color; because a part of the resinous earthy portion is mixed and diffused in the water by means of the saponaceous extractive prin-

and neutral salts, which may coagulate in some measure the vegetable matters, and leave the colorific particles disengaged; so that they may apply themselves to the stuff, or to the abovementioned earths. These salts are also useful by heightening certain colors; all acid salts and alum having the property of heightening the red colors of vegetables. The metallic salt used in the *scarlet* dye (which consists of a decoction of *cochineal*, to which a solution of tin in aqua regia, and some tartar are added) has also the effect of changing the crimson color of cochineal to a vivid scarlet; and probably has also the other effects of alum, of affording an earth, namely that of tin, to which the coloring particles may adhere, and of coagulating the vegetable matters, so that they shall leave the coloring particles detached and suspended in the water. The chief difference then betwixt the false and true dyes is, that the coloring particles in the former dyes are applied to stuffs, together with some gummy or resinous matter to which they adhere, and are therefore liable to be washed out along with these matters by any liquid capable of dissolving gums or resin; while the coloring particles of the true dyes are applied to stuffs, either alone, or adhering to some fine earth, as the earth of alum or of tin; and as both the coloring and the earthy particles are unsoluble in any liquids, to which they are most apt to be exposed, as water, soap-suds, &c. they are capable of resisting the action of these liquids, and are therefore durable. Some dyes are also called *false*, because their colors are depraved by exposure to the sun and to the air. These effects cannot, I fear, be explained without a further knowledge of colors, and of the action of light and air upon colors, than has hitherto been communicated. We here treat not of the causes or changes of colors, but of the application and adhesion of coloring particles. To confirm our conjectures on this subject, we may observe, that when the coloring particles of vegetables and animals are diffused in an alkaline lixivium, by means of gummy, resinous, or oily matters to which they adhere, they may be separated from these adhesive matters by adding alum, the acid of which unites with the alkali of the lixivium; while the coloring particles apply themselves to the basis or earth of the alum, now disengaged, with which they form what are called by painters *lakes*, the coloring matter of which is not now soluble in water or in spirit of wine; although these liquids are capable of extracting that coloring matter from the vegetable and animal substances which contain it, by the intervention, as we suppose, of some gummy or resinous matters.

For further particulars concerning dying, and the chemical history of dying substances, *see* BLACK, BLUE, CRIMSON, &c. and COCHINEAL, INDIGO, FLOWERS, FRUIT, LEAVES, &c. The *details* of the particular processes in this art are described fully by *Mr. Hellot*, in his Treatises on the *Art of Dying*.

ciple. If a ſtuff be plunged in a decoction of ſuch ſubſtances, the coloring particles are thereby made to touch and apply themſelves to it, and even to adhere firmly; becauſe the reſinous earthy coloring principle, when once united to the ſtuff, and ſeparated from the extractive principle, is no longer ſoluble either by water, ſoap, ſalts, or other active matters. Several ſubſtances are known, the coloring principles of which are in this ſtate. Of theſe the chief are the *green ſhells of wallnuts*, the *root* of the *wallnut-tree*, *ſumach*, *ſaunders*, *bark of alder*, and the ſhell-fiſh called *murex*, ſuppoſed to be the purple dye of the ancients. Excepting this latter ſubſtance, which gives a fine red, all the reſt give a dun color, called a *root-color*, but which is valuable notwithſtanding its little luſtre; becauſe it is very uſeful as a ground upon which other brighter colors may be applied. From the nature of theſe coloring ingredients we may perceive that no preparation is neceſſary for the colors, or for the matters to be dyed. They furniſh the ſimpleſt and moſt practicable kind of dying; for all the operation conſiſts in boiling the dying materials in water, and in dipping the ſtuff to be dyed in this decoction.

The coloring principle of another kind of ſubſtance is contained in a matter altogether reſinous, which is ſo diſpoſed that it cannot be rendered miſcible with water by means of the ſaponaceous extractive principle of the ſame ſubſtance. The principal ingredients of this kind are *indigo*, which furniſhes the blue dye, and the flowers of *cartamus*, or *baſtard Saffron*, from which a very beautiful red is procured. Pure water cannot extract the colors from theſe matters. The blue reſinous part of indigo is alſo of the nature of thoſe which ſpirit of wine cannot diſſolve: but as fixed alkaline ſalts are capable of acting upon all reſinous matters, they are uſed ſucceſsfully to extract the coloring parts of theſe ingredients, and to render them fit for dying.

The coloring principles of almoſt all the other vegetable and animal matters which furniſh colors for dying, and which are very numerous, are of a purely extractive ſaponaceous nature, and may conſequently be eaſily extracted by water alone; but as they are ſoluble in water, they might eaſily be waſhed away from the ſtuffs to which they have been applied, if theſe ſtuffs had not previouſly been impregnated with ſome matter capable of producing ſome change or decompoſition on the coloring part.

A method has been found of fixing colors upon ſtuffs by different ſalts, with which the ſtuffs are impregnated before they are dyed. The extractive coloring particles are ſo changed by theſe ſalts, that they loſe their property of being ſoluble in water, and are even rendered capable of reſiſting the action of ſoap, and other ſubſtances which are apt to deſtroy moſt colors, and are therefore uſed to prove the durability of theſe.

Of all the ſalts which may be employed for this purpoſe, *alum* is found to be the fitteſt: it is therefore generally employed for all extractive tinctures, which are very numerous, the principal of which are *luteola*, or *dyer's-weed*, and all the herbs which give a yellow color, *madder*, *vegetable kermes*, *cochenil*, *Braſil-weed*, *log-wood*, and other woods and roots uſed in dying. Alum is not the only ſalt which has this effect. All neutral ſalts with metallic baſes are alſo capable of fixing the extractive colors: but ſome of theſe are very dear, and others change and ſpoil the colors; ſo that alum is ſolely employed for this purpoſe.

All thefe dyes cannot be equally well fixed by alum, or by the other falts above-mentioned. Some of them are only fo much fixed by alum as to refift the action of water, but not of the other fubftances ufed to prove the fixity of colors, nor even of the air, during a long time. This latter kind of dyes are called *falfe* or *fmall tints*, to diftinguifh them from the more fixed dyes, called *great* or *good tints*.

Thefe differences muft proceed from the particular nature of each of the coloring materials : but very accurate analyfes of thefe materials, and a great number of new refearches muft be made, before this obfcure fubject can be explained. It will even appear ftill more obfcure, when we confider that the different nature of the fubftances to which the dye is applied, furprizingly affects the beauty and fixity of colors. For inftance, the red color of madder, which is fufficiently beautiful and fixed upon wool and cotton, gives but a falfe tint upon thread; alfo cochenil, which gives a vivid and bright flame-colored red to wool, and even to moft animal matters, does not adhere to filk, cotton, or thread. In the particular details of the proceffes for dying the different kinds of matters many other fingular differences may be found, which require particular attentions to be explained. The moft general inference from thefe particular details is, that wool and all animal matters are the moft eafily dyed; next to them, filk and other fubftances, which feem to be intermediate betwixt the animal and the vegetable nature; and laft of all, thread, and vegetable matters.

The few facts and general principles we have advanced on the art of dying are fufficient to fhew its connexion with chemiftry, and how much it may be improved by this fcience.

E.

CCXLV. EARTHS. Earth is one of the four ſimple ſubſtances called elements, or primitive principles; becauſe they are indeed the moſt ſimple of all thoſe which enter into the combination of compound bodies. We cannot doubt, in particular, that the greateſt part of the compounds which we can analyſe contain earth as one of their principles; for after art has exhauſted all its efforts to decompoſe them, a fixed and ſolid matter always remains, upon which no change can be produced; and this is what is generally called earth. It has the ſolidity, weight, fixity, and other principal properties of the maſs of ſolid matter which forms the globe we inhabit, called alſo *the earth.*

Theſe general conſiderations are ſufficient to convince us, that in nature a ſubſtance exiſts whoſe properties are different from thoſe of fire, air, water; and which is, like theſe other ſubſtances, one of the elements of compound bodies. But a vague aſſertion like this does not ſatisfy chemiſts. Beſides the aſcertaining of the exiſtence of the different ſubſtances ſubmitted to their examination, they require to know the properties of theſe ſubſtances in their greateſt degree of purity and ſimplicity: but they have found much difficulty and uncertainty in inveſtigating the eſſential properties of the pureſt and ſimpleſt terreſtrial element.

Earth is not found ſo pure as the other elements, fire, air, and water, which, though not entirely free from mixture, are however ſo pure, that we may certainly and eaſily diſcover their fundamental properties. Theſe properties of each of theſe pure elements are ſo well aſcertained, and ſo evident, that nobody has yet attempted to diſtinguiſh different kinds of fire, air, or water, notwithſtanding the differences which may ariſe from the heterogeneous ſubſtances with which they are almoſt always mixed.

But we cannot ſay the ſame of earth; for a conſiderable number of ſubſtances are called earths, becauſe they poſſeſs the principal properties of the terreſtrial element: but theſe ſubſtances, when examined more particularly, are always found to differ from each other ſo much in other reſpects, and to be ſo difficultly purifiable from heterogeneous matter, that we have not aſcertained whether only one ſimple and elementary earth, or ſeveral ones eſſentially different, although equally ſimple, exiſt.

The moſt general and moſt probable opinion is, that as only one kind of fire, of air, and of water, ſo only one kind of ſimple elementary earth, exiſts. Al-

chemists chiefly have endeavoured to discover this primary earth, not with an intention to ascertain its properties, but because they imagined that as gold is the purest of metals, the earth of which it is partly composed must be also the most pure; they have, therefore, searched every where for this earth, which they call *pure earth* and *virgin earth*. They have endeavored to obtain it from dew, rain, the air, ashes of vegetables, animals, and several minerals: but it was impossible to find it in compound bodies; for we shall see that when once this element makes part of a compound body, it cannot be disengaged from the substances with which it has united.

Some of the best philosophical chemists have rather chose to admit different kinds of elementary earths, than to investigate the nature of the most simple and elementary of all. Becker admits three principles, which he calls *earths*, namely, *the vitrifiable*, *the inflammable*, and *the mercurial earth*, which are known by the name of *the three earths of Becker*.

Mr. Pott, examining the principal natural earths, divides them into four kinds, *the vitrifiable*, *the calcareous*, *the argillaceous*, and *the gypseous earths*. This able chemist shews the essential properties of these four kinds of earths, without affirming that they are all equally simple, and without even determining which of them he considers as most simple.

As earth is an element which enters into the composition of almost all bodies, and which seems chiefly to affect their properties, it deserves an accurate investigation to discover which is the most simple and elementary of all the substances to which the name *earth* has been applied. This subject seems capable of decision by considering, first, what are the essential properties by which earthy substances differ from other elements, and then by determining that earth to be the most pure and simple, which possesses these properties most eminently and decisively; for we cannot doubt, that the properties distinguishing earthy matters from the other elements are the essential and specific characters of the earthy element; and also, that the more eminently any substance possesses these characteristic properties of the earthy element, the nearer it approaches to this element, considered in its state of purity and simplicity.

This being established, if we compare with the other elements all the substances which may reasonably be considered as earthy, we shall soon be convinced, that these possess much greater *weight*, *hardness*, *fixity*, and *infusibility*, than any other element; for these qualities are insensible, or do not exist, in the element of fire; they are in an exceedingly small degree in the air, and are more sensible and considerable in water; but are infinitely less than in any thing which can be considered as earth. Hence we ought to conclude, that the qualities above-mentioned are the distinguishing and characteristic essential properties of the earthy element. But these qualities are not so eminently united in any of those substances which are considered as earthy, as in that which is called by chemists, *vitrifiable earth*. We say then, that this earth is the heaviest, hardest, most fixed, and most infusible, and even the most *apyrous* of all earths, when it is very pure; and also that it is the most homogeneous, the most simple, and elementary earth, as we shall prove by a more particular examination of its properties, and by a comparison of these with the properties of the other earthy substances.

We call that *vitrifiable earth*, the integrant parts of which when united form masses of matter or stones, absolutely white and colorless, much more transparent and hard than any other natural substances, and which suffers no alteration, or even fusion, by the strongest fire which we can apply to it.

Amongst the hard stones called vitrifiable, we indeed know few which strictly possess all the qualities we have mentioned; because in very few of them the vitrifiable earth is pure. Most of these stones, as hard pebbles of all kinds, sand, free-stone, agates, quartz, rock-crystal, and the stones called precious, are deficient in some of the qualities required to constitute the purest vitrifiable earth. Some of them are opake, or only semitransparent; others are colored; some are fusible by a great heat; and, lastly, others, although much harder than any other kind of stones, want the last degree of hardness; all which prove that they are mixed with heterogeneous substances, chiefly phlogistic, metallic, or even earthy, of a different kind.

The purest of all the vitrifiable stones is the diamond, which is perfectly white, free from all color or stain, and transparent. This stone is also known to be the hardest of all, is absolutely apyrous, that is, incapable of receiving any alteration by the most violent heat. We, therefore, consider the matter of this stone as the purest, simplest, and most elementary earth that is known. The properties, then, of this stone, and of the other vitrifiable stones which resemble it, may give us notions of the properties of primary, elementary, unchanged earth. In this our opinion is conformable to that of the illustrious Stahl, who indeed admits the three earths of Becker; but, at the same time, corrects the theory of this chemist, by declaring that he only considers the first earth of Becker, or vitrifiable earth, as the proper terrestrial or earthy element. *Specimen Beckerianum*, p. 44. No. 25.

But before we particularly enumerate the properties of this earth, we ought to make some observations on those hard, earthy, and stoney matters called by chemists *vitrifiable*.

Our first observation shall be concerning the name *vitrifiable earth*; because it may produce false notions of the nature of these stones.

We say then, that the epithet, *vitrifiable*, is given, first, because some stones of this kind are, by means of their heterogeneous matters, capable of fusion and conversion into glass, without addition, and merely by the action of a very violent heat; and secondly, because other stones of this kind, which are less fusible than these now mentioned, but which are yet more so than stones of other kinds, require for their perfect fusion and vitrification a less quantity of flux, and a less degree of heat.

In the second place, as all the earths and stones called vitrifiable have, notwithstanding their impurity, more hardness and transparency than others, and are fitter to communicate these good qualities to glass, they are employed preferably to any other earths in the composition of glass, or artificial crystal. These are the only reasons why this kind of earth has been called vitrifiable. But we ought not from thence to conclude, that the earthy substance which almost entirely composes them is more fusible and more vitrifiable than other earths: on the contrary, I again say, that vitrifiable earth, when very pure, is of all earths the least fusible, and the least vitrifiable. I was present at a fine experiment made relatively to this subject. Some diamond powder was mixed with a

ſufficient quantity of fixed alkali to vitrify any other earthy matter, and the mixture expoſed to a heat ſufficient for the moſt difficult vitrifications. After the operation, no glaſs was found in the crucible; but part of the alkali had been diſſipated by the violence of the heat, and the diamond powder did not ſhew any ſigns of a beginning fuſion. Thus we may conſider it as an eſtabliſhed truth, that the earths and ſtones called vitrifiable are not eſſentially and really ſo; that the fuſibility of ſome of theſe, by which property they are rendered the fitteſt earths for vitrification, proceeds from heterogeneous matter with which they are mixed; and that, in general, the whiteſt, cleareſt, moſt tranſparent and hardeſt of theſe ſtones are alſo the moſt refractory and unfuſible. *See* VITRIFICATION.

Our ſecond obſervation ſhall relate to the weight of vitrifiable earths. We have already ſaid, that the pureſt and ſimpleſt of all earths ought to be alſo the heavieſt; and accordingly we find that pure vitrifiable earth is ſpecifically heavier than calcareous, argillaceous, gypſeous, or other earths. We are, nevertheleſs, no leſs certain, that metals, metallic earths, and ſeveral kinds of ſpars, both calcareous and ſelenitic, are much heavier than the moſt compact vitrifiable ſtones: but we muſt conſider that theſe earthy matters are very compound bodies in compariſon of the purer earths. An objection may be made, that if elementary earth be eſſentially the heavieſt of all matters, then any body compounded of this earth and other matters ought to be lighter than pure earth. This objection would be unanſwerable, if the ſpecific gravity of a body was always equal to the ſpecific gravities of the integrant and conſtituent parts which compoſe it: but as theſe parts may be ſo arranged that void ſpaces may be left betwixt them, ſometimes larger, and ſometimes leſs, therefore a body compoſed of parts eſſentially lighter, may yet have a greater ſpecific gravity than another body whoſe parts are eſſentially heavier; and this happens in all metals and metallic matters. *See* METALS and METALLISATION. Thus the gravity of metals and of metallic earths and ſtones ought not to prevent our conſidering the pure and elementary earthy principle as the heavieſt of all natural ſubſtances.

After theſe explanations, we may conſider the properties of elementary earth in the pureſt vitrifiable ſtones, and may compare them with the properties of the other elements. Since of theſe elements water is the moſt capable of our examination, we ſhall compare it with the pureſt vitrifiable earth; obſerving always, that we conſider theſe elements in their ſtate of aggregation; for we have no method by which their primary integrant parts can be known and conſidered ſeparately.

If then, on one ſide, we conſider a maſs of water, abſolutely pure, expoſed to a cold ſufficient to form it into hard, compact, ſolid ice; and if, on the other ſide, we compare to this a maſs of vitrifiable earth, as a diamond, or even a very fine and clear rock-cryſtal, we ſhall eaſily perceive that theſe two matters reſemble perfectly each other in their appearance; we ſhall find that both of them are colorleſs, inodorous, and taſteleſs; and that their tranſparency is alike: therefore, if we could no further examine their properties, we muſt conſider them as being of the ſame matter: but when the other properties of theſe ſubſtances are examined, as weight, hardneſs, fuſibility, and fixity, then we ſhall perceive differences, which indeed are only in the degrees of theſe properties

poſſeſſed

possessed by each of the two substances: but the difference of these degrees is very great. Thus the specific gravity of rock-crystal is almost four times that of ice: their hardness also is so different, that the earthy substance resists the point of the hardest steel, without being scratched; and when struck by steel, elicits ignited sparks; while ice may be easily cut by instruments of steel, and does not elicit sparks when struck: their difference of fusibility is still more sensible, the ice becoming fluid by a gentle warmth, which does not sensibly affect rock-crystal in any respect. I say, *sensibly*; because with the least diminution of cold it is certainly somewhat affected, so far as to be expanded, and consequently to be less hard and heavy. But these two latter affections, particularly, are so inconsiderable in a vitrifiable stone with the heat necessary to thaw ice, that probably it cannot be estimated. Lastly, if we continue to examine these two substances by a heat gradually augmented, we shall see the water totally dissipated in vapors, before even either of these substances has become red-hot, and the vitrifiable stone support a heat almost infinitely encreased, till it is white and dazzling, without becoming fluid, or without any part of it exhaling in vapors; for it may be afterwards found to have lost no weight by having been exposed to this heat.

So far we can extend our examination; for I do not believe that a pure vitrifiable earth, as a diamond, can be fused even in the focus of the best burning speculums: but supposing that a sufficient heat might be produced to procure this fusion, or that this stone were exposed to infinitely greater heat, such as we conceive to be in the body of the sun, it would then melt, and would even be reduced to vapors, if the heat were sufficiently violent; and when this heat should cease, it would, when it cooled, fix again, and become such a substance as it was before. The same would happen to vitrifiable earth in these circumstances, which does happen to water rendered fluid, and reduced to vapor by a certain heat, and which is again frozen into solid ice when that heat is removed. The differences, therefore, betwixt these two substances are only, as we have already said, in the degrees; but also these differences are very considerable.

From these considerations an inference seems deducible, that the elements or the simplest substances which we know are essentially only one and the same matter, and only differ from each other in the quantity and in the form of their primary integrant molecules, which, from this difference of form and quantity, have a greater or less tendency to unite together; and we might be inclined to believe that a certain kind of analogy or gradation exists betwixt them: thus, for example, that earth should be to water, what water is to air, and what air is to fire, or rather to some unknown intermediate substance betwixt air and fire; for the difference betwixt these two latter elements appears too great to be compared with the differences amongst the three former. But these are speculations entirely systematic; for we are very far from being capable of estimating the essential properties of elements sufficiently exactly, to be able to determine any thing precisely and positively in this respect.

However that may be, we cannot doubt but that earth chiefly differs from the other elements by the powerful tendency which its parts have to each other, and by the force of their cohesion. For its hardness, fusibility, fixity, and even its gravity, are evidently the necessary consequences of this principal and essential property. And by this property does the earthy element act in the system of nature. By this it is the cause of the consistence of all solid bodies.

It

It receives, fixes, and incorporates in some measure the other elements.

Lastly, as without fire the whole world would be one mass of solid and immoveable matter, so without earth it would be a confused heap of fogs, vapours, a chaos of incoherent atoms, destitute of that harmony and equilibrium which sustain it.

We have already had occasion to shew in several parts of this work, that the general tendency of the parts of matter to each other is the grand spring of the universe; that by this power, all combinations, solutions, and, in a word, all the movements and operations of nature are performed: and as we have shewn that the earthy element possesses this tendency in the greatest degree, we ought to consider earth as being in this sense the most active and powerful of all elements. This notion is contrary to the opinions of chemists and philosophers, who from not having sufficiently examined this subject, and being deceived by the seeming inactivity of earth considered in its state of aggregation, have affirmed it to be an element purely passive, and only capable of impulse from other elements. Indeed when the parts of earth are united together, they appear to be, and really are, incapable of acting upon other bodies, because they then exhaust all their action mutually upon each other. But the force with which they adhere together, and which renders them incapable of forming other unions, the extreme hardness and insolubility of a mass of pure earth, ought to demonstrate to a true philosopher, that if we suppose the parts of earth so separated from each other, that they cannot unite, and exhaust their action upon each other, they must then possess all their force of tendency, which must be very great, they must be in a state of violent effort, and consequently must tend with extreme force to unite with any parts of matter which may be within their reach, and to which they can apply themselves. We do not indeed know any pure earth which is in this state of broken aggregation: but we know compounds in which the primitive integrant parts of the earthy element are only combined with the parts of water, which are incapable of satisfying all their tendency to union. These are the most simple saline substances, such as acids and alkalis; and we may judge by the force and vehemence of the action of these solvents, how violent the action of the parts of earth would be, which should be capable of exerting all the attractive force which belongs to them.

Although the entire mass of our globe be probably formed by an immense heap of elementary, vitrifiable, and even actually vitrified earth, as the illustrious Buffon believes, we do not find upon its surface but a very small quantity of this earth, unaltered, and in its primary state. Perhaps even none of it exists in that state: for, as we have observed, the common vitrifiable stones, which are chiefly formed of it, are very far from the degree of purity of primitive elementary earth; and even perfect diamonds, which seem of all these stones to approach the nearest to this purity, seem to have been elaborated by the waters, if we can judge from their regularly crystallized form.

We shall not be surprized at the scarcity of pure earthy element, if we consider that the surface of the earth, which alone we are acquainted with, has been from the beginning of the world exposed to the constant action of the other elements; and that by uninterrupted operations, nature, assisted by

fire,

fire, air, and water, has gradually disunited the integrant parts of elementary earth, and by combining them in manners and proportions infinitely various with parts of the other elements, has formed the numberless compound bodies, which occupy a certain thickness near the circumference of the globe, probably very small in comparison of the diameter of the earth, but very large with regard to us, whose greatest efforts only extend to a few hundred feet below its surface.

All the portions of elementary earth, which, having been thus disunited, have afterwards been combined with parts of matter of other kinds, have received very sensible changes, the effects of which always remain, and prevent them from appearing afterwards, notwithstanding future decompositions, in their original purity and simplicity. They then assume different forms according to the nature of the compounds into the combination of which they have entered. Thus, for example, the earth which makes parts of crustaceous animals, or rather of their shells and scales, takes the character of that earth which is called *calcareous*, and which is capable of conversion into quicklime by the action of fire. The earth which has entered into the composition of plants, and even of the bodies of animals, after having been deprived as much as is possible of the principles of these compounds to which it was united, forms all the *argillaceous earths*. Some of these are found which partake both of the calcareous and of the argillaceous properties, and are called *marles*. Marles have not yet been sufficiently well examined by chemists. They are either a mixture of clay and calcareous earth, or they have been so elaborated by nature as to be transformed into a particular earth, partly calcareous, and partly argillaceous, such as the earth of animal bones seems to be.

As the earth which forms sands and the common impure vitrifiable stones retains more than the rest the essential properties of elementary earth, notwithstanding the heterogeneous, phlogistic, and other parts with which it is mixed; we cannot easily know whether it has once made a part of some very compound bodies, from the principles of which it has been more perfectly separated than the argillaceous and calcareous earths; or whether it be the primitive earth, which, without having made part of any intimate combination, has only been divided and conveyed by waters, and the parts of which have afterwards reunited, having only contracted a slight union with some phlogistic, metallic, and other matters, with which it is found mixed. This latter supposition appears to me to be the most probable. But very extensive researches in natural history and in chemistry are requisite to determine this question.

From what we have said concerning the principal kinds of earths which form the surface of the globe, we may conclude, that excepting the purest vitrifiable earth, all the others are mixed with heterogeneous matter. By these remaining heterogeneous matters are the different kinds of earth specified and characterised: and as they all preserve and retain their peculiar character, we ought to conclude from thence that these extraneous matters are very intimately united. To purify and simplify these mixed earths, so that they shall be assimilated to the purest vitrifiable earth, would be a fine problem. But, probably this problem is beyond the power of our art. For as in general

the perfect separation of two substances, united together, is exceedingly difficult, this difficulty must greatly increase, when one of the two substances to be separated has a very strong attractive power, as earth has. This is the true reason why we find so small a portion of pure earth amongst the bodies within our reach; and that on the contrary, the globe is covered with so great a quantity of earthy substances differing from each other so much, that we might be inclined to believe them to be bodies essentially different. *See the articles*, EARTH (CALCAREOUS), EARTH (VITRIFIABLE). (*u*)

CCXLVI. EARTH (ANIMAL). (*x*)

(*u*) In this article the author has advanced some ingenious speculations, but in my opinion several of his propositions are affirmed without proof, and some of his inferences are not conclusive. The subject does not appear to me capable of being treated so decisively. Most philosophers, ancient and modern, have enumerated, according to their theories, the *elements* of which they believed all substances to be constituted. Nevertheless, they have not yet proved the existence of any one element. The impossibility even of such a proof appears from considering, that the only reason which can induce us to believe that any substance is an element is, that we are incapable of decomposing that substance; and that our incapacity to decompose does not necessarily imply an impossibility of decomposition. The improbability of the conjecture that fire, air, water, earth, are the only elements, might easily be shewn. If we mean by element whatever substance we are incapable of decomposing, (and this is the only precise meaning which can be formed of it) then many other substances are entitled to be enumerated amongst elements. According to this meaning the number of elements will decrease, when means of decomposing some of those which cannot now be decomposed are discovered. The author believes that only one kind of elementary earth exists, and he further believes that this earth is that which he and some other authors call *vitrifiable*. But besides that the class of earths called vitrifiable contains many substances, the properties of which are exceedingly different, no proof can be given that those substances which are believed to be the purest of this class of earths, as diamonds, are more simple and elementary than calcined calcareous earths, argillaceous earths, earth of magnesia, metallic or many other earths; all which, when purified by ordinary methods, are as incapable of decomposition as diamonds are, and consequently as well entitled to be considered as elementary.

Earths are divided by Mr. Pott into vitrifiable, argillaceous, calcareous, and gypseous. The author of the Dictionary follows this division. Other authors have invented other divisions, and enlarge the number of classes, by which their dispositions are more comprehensive and distinct.

But although these arbitrary arrangements of natural substances may assist learners, yet as they are all very imperfect, our knowledge will be also very imperfect, unless we consider separately each species. In the notes to this Dictionary, therefore, the chemical properties of each species, as well as of the genera and classes of earths, (in which are comprehended, not only substances, commonly called earths, but also stones, slates, spars, and talks) shall be mentioned as the names of these species occur in the alphabetical order.

(*x*) EARTH (ANIMAL) is the earth of shells of animals, or that which is obtained by calcination or putrefaction of animal substances. 1. The *earths of the shells of Sea Fishes* have the general properties of calcareous earths. *See* EARTHS (CALCAREOUS). It differs from the mineral calcareous earths in being difficultly soluble by vitriolic acid, and in being less disposed to vitrify along with salts and metallic glasses. The *shells of eggs* are also calcareous, but are somewhat fusible by fire. 2. The *earths of calcined bones and horns* are soluble by nitrous, marine, and vegetable acids, and with difficulty by vitriolic acid; but are not calcareous. They are said to be unfusible, even when mixed with salt, metallic glasses, and other fusible mixtures. They are therefore used in the composition of enamels and opake white glasses.

CCXLVII. EARTH (ARGILLACEOUS). See CLAY.

CCXLVIII. EARTH (CALCAREOUS). Chemists have given this name in general to all earths and stones, which being burnt acquire the properties of quicklime.

Nature presents to us a considerable quantity of calcareous earths and stones, which have peculiar differences depending on their greater or less purity, but which resemble each other by essential properties common to all, and particularly by their capacity to receive calcination.

The principal kinds of these earths or stones are, chalks, all the calcinable shell-stones employed for building, all marbles, calcinable stalactites, the alabasters and spars which are convertible into quicklime by fire.

Amongst these stones a great number are evidently impure and mixed, particularly those which are colored. But amongst the whitest, we cannot easily ascertain which of them contains the purest earth, because they have not been chemically compared with this view. We ought certainly to consider those as the purest which possess in the highest degree the essential properties of calcareous earth.

All calcareous stones are less hard than vitrifiable stones; none of them strike fire with steel, and they all may be easily cut with steel instruments; some of them may be found, whose parts having been divided, conveyed by waters, and afterwards deposited successively upon each other, form concretions, or rather crystallizations, very neat and even transparent. Their transparency however is always less than that of the purer vitrifiable stones.

The specific gravity of the different kinds of calcareous stones has not been compared with the specific gravity of the vitrifiable. We only know that some calcareous spars are much heavier than the precious stones, and are therefore called *heavy spars*. But as we are very certain that the weight of these bodies is caused by extraneous and not calcareous matter, this does not prevent our establishing a general rule that calcareous earth is less heavy than vitrifiable; for, excepting the instance now mentioned, they all are so.

If any calcareous earth or stone be divided by trituration and moistened with water, it absorbs a certain quantity of it, particularly if it be very dry; and it forms a kind of paste, the parts of which have a certain adhesion together. But this paste is not so ductile as that formed by clay and water. It also dries and disunites much more quickly.

glasses. Nevertheless, Wallerius affirms, that the earth of calcined bones, by intense heat, was changed, without addition, to a green glass. See *Mem. Sued.* 1760. The same author says, that the earth of the whites and yolks of eggs was easily fusible, and that in general the fusibility of animal earths is in proportion to the softness of the parts from which they were obtained. 3. The *earth of blood, flesh, and skins* of animals, is soluble by all acids, and is fusible by fire; that of blood and of other animal fluids being most fusible. This earth, like that of burnt bones and horns, is not calcareous; but both these kinds of earth are said to be rendered calcareous by being dissolved in acids, precipitated by fixed alkali from those acids, and afterwards calcined. They probably contain some oleaginous substance, from which they cannot be entirely divested by fire without a previous solution in acids.

All acids are evidently capable of acting upon calcareous earth; they attack and dissolve it with more or less effervescence. This action of acids upon calcareous earths and stones furnishes us with an easy method of distinguishing them from other earth and stony matters, which they resemble externally.

Calcareous earth saturates all acids, and forms with them different *neutral salts with bases of calcareous earth*, according to the kind of acid.

With vitriolic acid, it forms a crystallizable salt, not very soluble in water, called *Selenites*.

With nitrous and marine acids, it forms acrid, bitter, and very deliquescent salts. They are called *nitre*, and *marine salts with calcareous bases*.

With the acid of vinegar, calcareous earth forms a salt not deliquescent, and susceptible of a silky and ramose crystallization like a kind of vegetation. This is *acetous salt with calcareous basis*.

Lastly, with acid of tartar, this earth forms a neutral crystallizable salt, a *soluble tartar with calcareous basis*. This salt is much more soluble in water than pure acid of tartar.

Calcareous earth has also the property of decomposing all ammoniacal salts, from which it disengages the volatile alkali, and unites with their acids, when assisted by a certain heat.

Calcareous earths and stones, being exposed to the action of fire, lose part of their weight, and much of their consistence, which proceeds from the fire carrying off a considerable quantity of water which enters into their combination; and as the last portions of water are powerfully retained by earth, a very strong heat is requisite to dissipate them; and in this principally consists the change produced upon calcareous stones when reduced into quicklime. *See* QUICKLIME.

The most violent fire we can make is incapable of melting and vitrifying calcareous earths and stones, when they are very pure (y); but a very remarkable thing is, that these substances, so refractory when alone, become true fluxes, and facilitate the fusion and vitrification of several other substances, as sands and clays. This phenomenon, the cause of which is hidden, and not easily to be discovered, seems to depend on a particular disposition of the inflammable principle from which none of these matters is entirely exempt, and perhaps on some remaining portion of watery principle, so strongly retained by calcareous earth, that fire cannot entirely extricate it. *See* VITRIFICATION.

The other characteristic properties of calcareous earth are the same as the properties of this earth when converted into quicklime, which we shall relate and explain under the article QUICKLIME. We shall only here observe, that if we add to these the properties of calcareous earth before calcination, we shall evidently see that all these properties, and the phenomena arising from them, depend on the intimate union of a certain quantity of watery principle with the earthy principle in calcareous earth; an union which produces an incipient saline combination, according to Stahl's theory, and a strong disposition in cal-

(y) Mr. D'Arcet found that chalk, limestone, and one calcareous spar, resisted a violent, long continued heat; but that other spars, stalactites, and other calcareous substances, shewed a beginning fusion. *See Mem. l'Acad. des Sc. sur l'Action d'un feu violent, égal, & continué,* 1766.

careous

careous earth to paſs into a more compleat ſaline ſtate by a more perfect combination with water. We may hence eaſily perceive, that as calcareous ſtones in their natural ſtate do not differ from vitrifiable ſtones but in being leſs hard, leſs heavy, and leſs fixed, which are preciſely the eſſential qualities by which pure water differs from pure earth; that as, beſides the action of fire deprives calcareous ſtones of much water, calcareous earth chiefly differs from vitriſiable earth by its union with water; and laſtly, that as we cannot doubt but that all calcareous earth has been once one of the principles of organiſed animal bodies, we cannot alſo doubt, but that the water, the portion of phlogiſton (z), perhaps alſo ſome remaining ſmall part of ſaline matter, which are found in theſe earths, and which diſtinguiſh their different kinds, are the remains of the principles with which the elementary earth was found combined in theſe compounds, and which continue firmly united with them. (a)

CCXLIX. EARTH (GYPSEOUS). This name is applied by ſome chemiſts to gypſum, and to the earth contained in ſelenites. As the

(z) Moſt, perhaps all calcareous earths contain ſuch a portion of phlogiſton, as to enable them, by means of heat, to reduce metallic calxes, eſpecially thoſe of lead and biſmuth, which are eaſily reducible, and even in ſome meaſure thoſe of copper and iron. By means alſo of this phlogiſton they acquire a phoſphoric quality when united with nitrous acid. *See* PHOSPHORUS *of* BALDWIN. A curious experiment is mentioned by Mr. Pott, which ſhewed this phoſphoric quality of calcareous earth united with nitrous acid. He ſaturated that acid with quicklime, and diſtilled it. He repeated this operation frequently, always uſing the ſame acid and the ſame quicklime. He perceived that the vapors which paſſed in theſe diſtillations through a hole in the receiver appeared luminous ſparks, which afterwards kindled, and flowed out like a ſtream of fire. He alſo perceived another remarkable circumſtance in this operation, namely, that the effervescence which happened on the mixing theſe two ſubſtances, became each time greater than it had been in the preceding experiment. Whence did the quicklime acquire the fixable air which cauſed theſe effervescences? Was it from the acid? *See* POTT's *Diſſertation on Quicklime.*

(a) *Calcareous earths may be combined* with acids, with which they form neutralized earthy ſalts. *See* SALTS. They alſo readily unite with fixable air, in which ſtate of combination they are always found native. When uncombined with fixable air, or in the ſtate of quicklime, they may be combined with water, forming lime-water. *See* WATER (LIME), AIR (FIXABLE), CREAM *of* LIME, *and* QUICKLIME. In this uncombined ſtate they alſo may be united in ſome degree with ſulphur, forming a kind of hepar of ſulphur, and imperfectly with oleaginous ſubſtances forming kinds of ſoaps.

Calcareous earth, although infuſible by fire (*ſee the above note* [y]), may be rendered fuſible and vitreſcible by addition of fixed alkaline ſalt, of borax, of ſedative ſalt, of ſalt of urine, of metallic calxes, of gypſeous and argillaceous earths, of fuſible ſpars, and according to Mr. Pott, of ſparry quartz, of glaſs-gall, and of fixed ammoniac. Mr. Gellert, in his Table of Solutions, places calcareous earth amongſt the ſubſtances incapable of uniting with gypſeous earths. Nevertheleſs, the experiments of Mr. Brandt and of Mr. D'Arcet evince the fuſibility of calcareous earths mixed with gypſum. This however may be obſerved, that I have found from experiments, that ſuch mixtures are fuſible only when expoſed ſuddenly to a violent fire; and that by a gradually raiſed fire they are calcinable into quicklime. The cauſe of which ſeems to be, that the vitriolic acid of the gypſum is neceſſary to the fuſion; and that this acid, by a long continued heat not ſufficiently intenſe to occaſion a fuſion of theſe two earths, may be diſſipated, leaving its calcareous baſis behind, which together with the calcined earth forms an unfuſible maſs or quicklime. *

earth of gypsum, when separated from the vitriolic acid, does not appear to be different from pure calcareous earth, we refer to the articles GYPSUM, SELENITES, *and* EARTH (CALCAREOUS).

CCL. EARTH (MERCURIAL). Mercurial earth is a substance, which, according to Beccher and other chemists, enters into the composition of many bodies, particularly the metallic, together with *vitrifiable earth*, and phlogiston, which that chemist calls the *inflammable earth*. But the existence of this mercurial earth has not yet been satisfactorily demonstrated. Metals and marine acid, of which also Beccher supposes the mercurial earth to be a constituent part, do indeed present some phenomena which may induce us to suspect that these substances contain a principle different from all those which we know. But these phenomena are not sufficient to establish with certainty the existence of this principle. *See what is said on this subject under the articles* ACID (MARINE), MERCURIFICATION, METALS, *and* METALLISATION.

CCLI. EARTH (VEGETABLE). (*b*)

CCLII. EARTH (VITRIFIABLE). The earth so called by chemists is the purest, simplest, and most elementary of all known earths. As we have mentioned all the essential properties of this earth under the general article EARTH, we refer for these properties to that article. We shall only observe here, that the stones formed principally by the union of the parts of this earth, and therefore called vitrifiable stones, are easily distinguished from all the others by their hardness, which is so great, that they cannot be cut by steel tools, and that they can elicit sparks from steel. They have also the property of giving sparks of light when one of them is struck against another; but it is then an internal fire, and ignited sparks are not emitted, as when they are struck by steel. This property of giving light by percussion also belongs to glass, porcelaine, and other vitrified matters. It seems to be a phenomenon depending on electricity.

(*b*) EARTH (VEGETABLE). From numerous experiments made by Wallerius we find that earths or ashes of vegetables have not all the same chemical properties, but may be reduced into three kinds or classes. The first class is the earth obtained by burning soft, spongy, and farinaceous plants. It is partly soluble by vitriolic acids. It is more fusible by fire in proportion as the plant from which it has been obtained was more nourishing. Thus the ashes of rye, barley, oats, mustard, and especially those of wheat and rice, were easily fusible, forming green transparent glasses. This fusion is not occasioned by any mixture of alkaline salt, for no such salt could be obtained from the ashes of the above-mentioned grains by lixiviation. The second class of vegetable earths is produced by burning the harder and less succulent plants. This earth is more soluble than the former in nitrous and marine acids, but is less soluble in vitriolic acid. This earth, after lixiviation, still absorbs moisture from the air. It is also fusible by fire, but not so easily as the former earth, and is less fusible in proportion to the hardness of the plant. The third class of vegetable earth is that which is obtained by burning wood. This earth is calcareous, and is more difficultly fusible in proportion as the wood from which it was obtained was harder. Accordingly, it has been observed by manufacturers of glass, that ashes of the hardest woods make the most unfusible glass. Garden mould, which consists chiefly of the earth of decayed vegetables, was also found to be fusible by fire. *See the Swedish Memoirs for the year* 1760. By putrefaction of vegetable substances, a calcareous earth is said to be obtainable.

Vitrifiable

Vitrifiable earth, when pulveriſed into very fine parts, and moiſtened with water, abſorbs but a very ſmall quantity of this liquid, and forms a paſte which has conſiderable adheſion, but no ductility. When it is made thin by water, it pours like an oily or viſcid matter: when it is of a thick conſiſtence, it does not preſerve the form given to it, but it ſinks and collapſes: it alſo dries very quickly and eaſily. If, on the contrary, this finely ground vitrifiable matter be left at reſt under water, its parts will unite and adhere together ſo ſtrongly, that a maſs ſhall be formed almoſt as hard as a ſtone. Hence when vitrifiable ſtones are ground with water, the matter muſt be continually agitated and ſtirred, and the mill muſt be turned without interruption; for if they are left but a little at reſt, they harden, and adhere ſo ſtrongly to the bottom of the mill, that the mill-ſtone cannot without difficulty be again ſet in motion. This inconvenience may be much diminiſhed by mixing the vitrifiable earth to be ground, with different earths, calcareous or argillaceous.

No vitrifiable ſtone or earth is ſoluble in any acid, unleſs its nature has been changed by having been intimately united with ſome other ſubſtance; as, for inſtance, by fuſion with a ſufficient quantity of fixed alkali: but it cannot then be conſidered as pure vitrifiable earth, as it has not then the properties of that earth.

As ſome ſtones externally reſemble vitrifiable ſtones, and which alſo reſiſt the action of acids, although they are not vitrifiable, the proof by acids is not ſufficient to aſcertain the nature of theſe ſtones. To this proof muſt alſo be added that of hardneſs, which is the moſt deciſive. Many impure and mixed vitrifiable earths and ſtones differ from each other by their colors, and other accidental particulars depending on the heterogeneous matters with which they are united.

Nature preſents to us many mixed earths and ſtones, or ſuch as are compoſed of many kinds of different earths, as the vitrifiable, calcareous, talky, argillaceous, gypſeous or ſelenitic, and even the pyritous or metallic. But we cannot enter into theſe details, which are the object of mineralogy. We ſhall obſerve, that when an accurate examination of theſe compound bodies is required, the nature and proportions of the component parts may be diſcovered by ſubmitting them ſucceſſively to the deciſive proofs which we have mentioned under the articles of the principal kinds of earths and ſtones, by which their nature may be diſcovered and aſcertained. *See in particular for the vitrifiable earths and ſtones, the general article* EARTH, *and the word* VITRIFICATION.

CCLIII. EARTH-WORMS. (c)

(c) EARTH-WORMS. Earth-worms, when moiſtened with wine, or with vinous ſpirits, to prevent their putrefaction, and ſet in a cellar in a wide-mouthed veſſel, are in a few days almoſt wholly reſolved into a ſlimy liquor. Stahl ſuppoſes that they are impregnated with a nitrous ſalt which they receive from the putrid matters amongſt which they live. When this liquamen of worms is mixed with a little fixed alkali, and, after the evaporation, is ſet to ſhoot, the cryſtals are nothing elſe than nitre. Six drams of extract were obtained by ardent ſpirit from four ounces of worms; and from the ſame quantity of theſe, one ounce, ſix drams, and a ſcruple of extract, by means of water. Thirty-two ounces of dried earth-worms yielded, by diſtillation, thirteen ounces and a half of volatile urinous ſpirit, one ounce of concrete volatile ſalt, four ounces and a half of empyreumatic oil, and eight ounces of a reſiduum, from which were obtained, by calcination and lixiviation, an ounce and a half of fixed alkali. *Neumann.*

CCLIV. EAU DE LUCE. Eau de luce is a kind of volatile, liquid soap, of a strong, penetrating smell.

This liquor is composed of the liquid volatile alkali made from sal ammoniac with quicklime, and of the rectified oil of amber, so mixed together as to produce a white milky liquor.

Eau de luce cannot be prepared without certain management; for if the volatile spirit of sal ammoniac and rectified oil of amber be simply mixed and shook together, a milky liquor will be produced, such as is required; but this color disappears soon when the liquor is allowed to rest; either because the volatile alkali compleatly dissolves the oil of amber when in small quantity, or because this oil disengages itself from the volatile alkali, and floats a-part when in considerable quantity. In both cases the liquor becomes clear and transparent; but the milky color is required in eau de luce. By the following receipt excellent eau de luce may be made.

Take four ounces of rectified spirit of wine, and in it dissolve ten or twelve grains of white soap; filtrate this solution; then dissolve in it a dram of rectified oil of amber, and filtrate again; mix as much of this solution with the strongest volatile spirit of sal ammoniac, in a crystal-glass bottle, as when sufficiently shook, shall produce a beautiful milky liquor. If upon its surface be formed a cream, some more of the oily spirit of wine ought to be added.

This receipt is given by the author of the French edition of the London Dispensatory. The receipt given in that work is very good, but is much improved by the observations, experiments, and remarks made by that author.

CCLV. EDULCORATION. Edulcoration is, properly speaking, the rendering substances more mild. Chemical edulcoration consists almost always in taking acids and other saline matters from substances to which they adhere; and this is effected by washing in much water. The washing of diaphoretic antimony, and of the powder of algaroth, till the water comes off from these substances quite pure, may be given as instances of edulcoration.

In Pharmacy, juleps, potions, and other medicines, are said to be *edulcorated*, by adding sugar or syrup.

CCLVI. EFFERVESCENCE. Effervescence is an intestine motion excited betwixt the parts of two bodies of different natures, when they reciprocally dissolve each other. Effervescences are commonly accompanied with bubbles, vapors, small jets of the liquid, and noise or hissing. All these phenomena are occasioned by the air which disengages itself in almost all solutions. Frequently also effervescences are accompanied with a considerable heat, sometimes exceeding that of boiling water. This heat is occasioned by the collision of the parts during their union. The degree of heat produced in effervescences is proportionable to the activity with which bodies are dissolved, to the quickness with which the solution is made, and to the quantity of substances re-acting upon each other.

The most sensible effervescences are observed in the combination of concentrated mineral acids with calcareous earths, alkaline salts, metallic substances, and oily matters.

Generally the substances which contain a sensible quantity of inflammable principle are those which in similar circumstances produce the most heat in

effervescing with acids. Of all acids, the nitrous produces the greatest heat, when it dissolves these bodies.

Thus, for instance, the heat arising from a solution of calcareous earth in nitrous acid is not nearly so great as that which arises from a solution of a metallic substance in the same acid, although these solutions are performed equally fast; and the heat which is produced by the combination of nitrous acid with oils is so great, that a flame is quickly produced.

Formerly the word *fermentation* was commonly applied to effervescences; but now that word is confined to the motion which is naturally excited in animal and vegetable matters, and from which new combinations amongst their principles take place. This distinction is very proper; for a simple effervescence is very different from a true fermentation. See FERMENTATION.

CCLVII. EFFLORESCENCE. By this expression chemists denote what happens to certain bodies, upon the surface of which a kind of meal or powder is formed.

Efflorescence is occasioned either by decomposition or by drying. That which happens to Cobalt, and most martial pyrites, is of the former kind; and the efflorescence observed on crystals of marine alkali, of Glauber's salt, of alum, of green and blue vitriols, and of several other salts, is of the latter kind.

CCLVIII. EGGS. The eggs of hens, of birds in general, and of several other animals, are composed of several distinct substances; 1. Of a shell or external coat, which in the eggs of birds has a certain hardness and consistence, although it is brittle. The matter of this shell is a fine, absorbent earth, soluble in acids; hence if these eggs be steeped in vinegar, or any other acid, they are rendered quite soft, because the acid dissolves and takes away all the earth of their shells. (d)

The parts of this earth are bound together by a small quantity of gelatinous matter. This matter becomes very sensible by an empyreumatic animal smell, and by the black color which shells acquire when exposed to fire.

The shell of an egg is lined internally with a very white, fine, and strong membrane. It resembles a very fine skin, and is entirely of animal nature.

These external coverings contain the substance of the egg, which is of two kinds; namely, a lymphatic, white, transparent, gelatinous, viscous, and gluey substance, called *the white of the egg*; and another substance also gelatinous, but almost opake, yellow, less gluey and viscous than the white. This latter, which is called *the yolk*, is of a spherical form, and is surrounded by the white. To the yolk is annexed a small portion of white gelatinous matter, thicker and tougher than the rest of the white in which the embryo is contained.

We do not intend here to examine anatomically the uses of these several parts of the egg; we will consider them only relatively to their chemical properties and principles. As eggs contain the embryo of the animal, and the nourishment proper for it in its first increase, they are proper to give as an example of the analysis of animal feed.

(d) The shells of eggs are not only absorbent, that is, soluble by acids, but also calcareous, or convertible into quicklime. The earth of the shells, and also the earth obtained by calcination of the other parts of the eggs, are fusible and vitrescible by fire. See EARTH (ANIMAL).

The white of an egg cannot be dissolved by acids or by spirit of wine. This latter solvent, far from dividing it, on the contrary coagulates it, by taking from it a great part of its water which renders it liquid.

The white of an egg is soluble and miscible with water, but difficultly, because of its viscidity. Spirit of wine poured into water which keeps it dissolved separates it, and precipitates it in form of a curd. In this respect, the white of an egg resembles gummy, mucilaginous, and gelatinous matters. It is, in fact, a matter entirely of the nature of animal jellies, but of that kind which are coagulable by heat. The white of an egg, exposed to a less heat than that of boiling water, is coagulated, hardened, and its transparency is almost entirely changed to a milky-white color. This substance contains no other principles which are volatile with the heat of boiling water, than water; for if whites of eggs be distilled in a water-bath, nothing but water is obtained. While they lose this water, they become more and more hard and horny; they resume their transparency, and acquire a yellow-reddish color; so that when they are dried as much as possible, they perfectly resemble horn.

If they are to be further analysed, they must be put into a retort, and exposed to a naked fire: then fetid empyreumatic oil with much volatile alkali is obtained; and in the retort, when the distillation is finished, a coal is left like that of other animal matters. From this analysis we see that the white of an egg is a perfectly animalised substance. *See* JELLY (ANIMAL).

The yolk of an egg is chiefly composed of a gelatinous matter like the white; for it also coagulates and hardens by heat; but it also contains a considerable quantity of mild fat oil, which is in some measure superabundant, and not combined, and, in short, in the same state as those oils which may be obtained from vegetable emulsive seeds by expression. Thus the raw yolk of an egg when mixed with water is not entirely dissolved, as the white is; but forms with it, on account of this oily part, a white milky liquor or emulsion. This animal emulsion is vulgarly called *hen's milk*.

This superabundant oil of the yolk of an egg may be separated from it, like that of most vegetable grains, by expression. But to make this operation successful, the yolk of an egg ought to be deprived as much as is possible of its water. For this purpose, the eggs are to be previously hardened, and the yolks are to be separated, dried, and even roasted in a proper vessel, till they become somewhat softened by the sweating out of the oil; they are then to be put into a press, and a fat, unctuous, yellowish, and sufficiently mild oil is procured, which readily fixes itself in the cold. This oil has the smell of roasted or fried eggs, from the drying and roasting given to the yolks before the expression. Probably this oil might be obtained by a slower and more careful drying without roasting, and consequently without any change or smell.

From this quantity of superabundant oil in yolks of eggs, we may perceive a remarkable resemblance betwixt the eggs of animals and vegetable seeds. This oil is found in all seminal matters probably for the same reason. *See* OILS (SWEET EXPRESSED).

As all eggs in general are composed of a very nourishing substance, and that those of many animals have a very agreeable taste, they have been much used as aliment. They are also employed in medicine and in the arts. The white of an egg is an ingredient in collyriums and cataplasms for diseases of the eyes; and

both

both the white and yolk in emollient and resolvent cataplasms. The oil of eggs is softening, relaxing, and lubricating. It is employed either singly, or formed into a pomatum with fat matters, in burns, chaps, contractions, and other similar diseases.

The white of an egg, from its solubility in water, and from its coagulating by fire or in spirituous liquors, is very successfully employed in pharmacy, for many uses of the kitchen, and for clarifying the juices of plants, whey, sugar, syrups, &c. *See* FILTRATION.

The white of an egg alone forms a varnish very white and very shining, which is applied to several kinds of work, and particularly to pictures. Lastly, the yolk of an egg, from its oily and viscid parts, is a proper intermediate substance for the mixture by trituration of oils with watery liquors, so as to form emulsions. Several good remarks are found upon this subject in Mr. Beaumé's Treatise on Pharmacy. *(e)*

CCLIX. E L E C A M P A N E. *(f)*

CCLX. E L E M E N T S. Those bodies are called by chemists *elements*, which are so simple, that they cannot by any known method be decomposed, or even altered; and which also enter as principles, or constituent parts, into the combination of other bodies, which are therefore called compound bodies.

The bodies in which this simplicity has been observed are fire, air, water, and the purest earth; for by the most complete and accurate analyses which have been made, nothing has been ever ultimately produced but some one, or more, of these four substances, according to the nature of the decomposed bodies.

These substances, although reputed simple, may possibly not be so, and may even result from the union of several other more simple substances: but as experience teaches us nothing on this subject, we may without inconvenience, and we ought to consider, in chemistry, fire, air, water, and earth, as simple bodies; because they really act as such in all chemical operations.

The elements are also called by chemists *primary principles*. *See* PRINCIPLES, FIRE, AIR, WATER, and EARTH.

CCLXI. E L I Q U A T I O N. *(g)*

CCLXII. E L U T R I A T I O N. *(h)*

(e) Mr. Reaumur found that eggs might be preserved during months or years, by being covered with mutton suet, or any other fat substance; which, by filling up the pores of the shell, excluded the air, which is necessary to putrefaction.

(f) ELECAMPANE. From thirty-two ounces of the roots of elecampane were obtained, by distillation, three scruples and a half of concrete oil, similar in many, but not in all its properties to camphor. This concrete oil is soluble in spirit of wine. Geoffroy remarks, that it resides in the exterior part of the root, near to the bark. From an ounce of the dry root six drams and a half of extract may be obtained by water, and from the same quantity two drams and a half by spirit. *Neuman.*

(g) ELIQUATION. This is an operation by which a more fusible substance is separated from one less fusible, by means of a heat sufficiently intense to melt the former, but not the latter. Thus an allay of copper and lead may be separated by applying a heat which shall melt the lead, but not the copper.

(h) ELUTRIATION is an operation performed by washing solid substances with water, stirring them well together, and hastily pouring off the water, while the lighter part remains suspended in the agitated water, that it may be thereby separated from the heavier part. By this operation metallic ores are cleansed from earth, stones, and other lighter unmetallic particles adhering to them.

CCLXIII. EMERALD. *(i)*

CCLXIV. EMERY. *(k)*

CCLXV. EMPYREUMA. Empyreuma is a ſmell proceeding from burnt animal and vegetable matters, when they are expoſed to a quick fire, particularly in cloſe veſſels.

Empyreuma is the peculiar ſmell of burnt oils. No other but oily ſubſtances can produce it. As all vegetable and animal matters contain oil, and as no other ſubſtance contains it, hence the empyreumatic ſmell muſt be peculiar to burnt animal and vegetable matters; and hence alſo we may diſcover oil wherever it may be by this ſmell, which is ſo diſtinguiſhable, that it is very ſenſible even when the quantity of oil is too ſmall to be diſcovered by any other method. If then we perceive an empyreumatic ſmell when we burn a ſubſtance in cloſe veſſels, we may conclude that this ſubſtance contains oil. If, on the contrary, no empyreuma be perceived, we may be aſſured that the ſubſtance does not contain oil.

CCLXVI. EMULSION. An emulſion is a watery liquor, in which ſome oily matter is diſperſed and diffuſed (but not diſſolved), by the intervention of a mucilaginous or gelatinous ſubſtance.

The ſtate of the oil in emulſions is the cauſe why they are opake, and of a milky-white color; for this milky appearance is given to all tranſparent bodies by others that have not a very diſtinct color, when they are mutually interpoſed and divided to a certain degree.

Nevertheleſs, water and oil ſlightly adhere together in emulſions, by the intervention of the mucilaginous matter; for oil agitated with water gives but a momentary appearance of an emulſion, and only during the agitation. When it is left to reſt, the oil preſently riſes to the ſurface.

All vegetable and animal ſubſtances containing an uncombined oil, and mucilage or jelly, being triturated with water, yield emulſions.

Moſt ſeeds and grains, all gum-reſins, gummy and reſinous juices, and yolks of eggs, are capable of forming emulſions with water. Laſtly, the milky juices of plants, milk, and the chyle of animals, ought to be conſidered as natural emulſions.

(i) EMERALD, *Smaragdus*, is a precious ſtone, contained by ſeveral unequal ſides and obtuſe angles, forming irregular priſms. Its color is green: with a moderately ſtrong heat it becomes blue, but recovers its original green color when cold. By expoſure to collected ſolar heat, emeralds were rendered white and of various colors, and ſoon afterwards were fuſed, by which they loſt part of their weight and hardneſs. See DIAMONDS. Emeralds have the property of ſhining in the dark after having been heated. They are the fourth in hardneſs from diamonds; nevertheleſs they are ſuſceptible of impreſſion from a file. Emeralds may be imitated by adding forty-eight grains of pulveriſed calcined verdegriſe, and eight grains of martial crocus, to four ounces of minium and two ounces of pure rock-cryſtal, previouſly calcined and levigated, and by keeping that mixture fuſed during twenty-four hours.

(k) EMERY. *Smiris*. Emery is a very refractory mineral containing a ſmall portion of iron. It is exceedingly hard, and is therefore uſed for the poliſhing of metals, glaſs, and hard ſtones. Some pieces of emery contain ſmall ſpecks of gold, and of copper. The mineral called by alchemiſts *ſmiris Hiſpanica*, and employed to adulterate gold, is with probability believed to be the metal now called platina.

CCLXVII. ENAMEL. Enamel is in general a vitrified matter, betwixt the parts of which is dispersed some unvitrified matter: hence enamel ought to have all the properties of glass excepting transparency. Enamels then are opake glasses, and their opacity and colors proceed from the unvitrified matter which they contain. The unvitrified matters which give opacity and various colors to enamels, are almost always metallic calxes. Receipts for making several kinds of enamel may be found in several books, particularly in Neri's Treatise on the Art of Making Glass, with Notes by Merret and Kunkel.

Enamels ought to be very fusible. They are employed to color or to paint several kinds of work which are made by great heat. The white enamel is used to cover the earthen ware called *Delf*, to which it gives the appearance of porcelain. With the other colored enamels this Delf ware, porcelain, and also the white enamel, are painted. *See* DELF-WARE. *(l)*

CCLXVIII. ENS MARTIS, and ENS VENERIS. These Latin names are given to the flowers of iron and of copper made with sal ammoniac, or rather to these two metals sublimed by this salt. *See* FLOWERS.

(l) Enamels are glasses containing some opake substance, that is either unvitrifiable or incapable of being vitrified with the degree of heat requisite for the fusion of ordinary glass. Of the latter sort are almost all the enamels used, they being mostly composed of glass mixed with metallic calxes; all which, not excepting the calx of tin, by more intense heat might be reduced to transparent glasses. The white vitreous composition which is the basis of all enamels is prepared, according to Neri, by melting together a hundred parts of frit of calcined flints, one part of pure salt of tartar, and a hundred parts of a calx of lead and tin. This calx is prepared by calcining together equal parts of tin and lead, and reducing the substance so calcined to a very fine powder, by bruising it, passing it through a sieve, boiling it in water, decanting the water in which the finer parts are suspended, evaporating the water, and drying the powder; and by repeating the calcination and subsequent operations upon the grosser particles, till they become as fine as the former. This composition when slightly fused is to be reduced to a powder, and formed into all the various colored enamels, by adding to it coloring substances. Thus by adding to six pounds of this composition, forty-eight grains of magnesia, a *fine white enamel* may be prepared; an *azure blue enamel*, by adding to the same quantity three ounces of zaffre, and sixty grains of calcined copper; a *turquois blue enamel*, by adding three ounces of calcined copper, ninety-six grains of zaffre, and forty-eight grains of magnesia; a *green enamel*, by adding three ounces of calcined copper and sixty grains of scales of iron; a *shining black enamel*, by adding three ounces of zaffre and as much magnesia, or by adding six ounces of red tartar and three ounces of the same magnesia; a *purple enamel*, by adding three ounces of magnesia; a *yellow enamel*, by adding three ounces of tartar and seventy-two grains of magnesia; *a sea-green or beryl-colored enamel*, by adding three ounces of calcined brass and sixty grains of zaffre; and a *violet-colored enamel*, by adding two ounces of magnesia and forty-eight grains of calcined copper. These are the receipts given by Neri, approved by Kunkel, and now successfully used. The intensity and continuance of the heat must be attended to, as the colors both of enamels and of the transparent glasses imitating colored precious stones, especially of those which contain magnesia, depend much on these circumstances. White enamels may be composed of other substances besides calx of tin. Merret proposes to substitute regulus of antimony. Calcined bones, and perhaps other white earths, may be used for the same purpose. Mr. D'Arcet found that gypsum mixed with white clay, or with clay and hard spar, formed very beautiful enamels. Perhaps some of these enamels would form preferable glazings to that made with calx of tin, for covering those kinds of earthen ware which require, in the baking, greater heat than is suitable to the common enamel.

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CCLXIX. E S S A Y. Eſſays are chemical operations made in ſmall, to determine the quantity of metal or other matter which is contained in minerals, or to diſcover the value or purity of any maſs of gold or ſilver.

We ſhall treat ſucceſſively of each kind of eſſay.

CCLXX. E S S A Y *of* O R E S. Before eſſays of ores can be well made, a preliminary knowledge of the nature of the ſeveral metallic minerals ought to be attained. Each metal has its proper and improper ores, which have peculiar characters and appearances: hence perſons, accuſtomed to ſee them, know pretty nearly, by the appearance, weight, and other obvious qualities, what metal is contained in a mineral. A good eſſayer ought to be very intelligent in this matter, that he may at once know what the proper operations are which are requiſite to the eſſay of any given mineral. Some remarks may be found on this ſubject under the article ORES.

As metals are very unequally diſtributed in their ores, we ſhould be apt to make falſe and deceitful eſſays, if we did not uſe all poſſible precautions that the proportionable quantity of metal produced by any eſſay ſhall be nearly the medium contained in the whole ore. This is effected by taking pieces of the mineral from the ſeveral veins of the mine, if there be ſeveral, or from different places of the ſame vein. All theſe minerals are to be ſhook together with their matrixes. The whole is to be well mixed together, and a convenient quantity of this mixture is to be taken for the eſſay. This is called the *lotting* of the ore.

As eſſays, particularly the firſt, are generally made in ſmall, eſſayers have very ſmall weights correſponding to the weights uſed in the great, that is, to the quintal or hundred pounds weight, to pounds, ounces, drams, &c. The eſſay quintal and its ſubdiviſions vary according to the difference of weights in different countries, and this occaſions ſome confuſion, when theſe weights are to be adjuſted to each other. Tables of theſe weights are found in treatiſes of eſſaying, and particularly in that written by Schlutter, and tranſlated and rendered more complete by Hellot, which contains all the details neceſſary for the ſubject.

The cuſtom is to take, for the eſſay quintal, a real weight of a gros, or dram, which in France is equal to 72 grains; but as the whole dram repreſents 100 pounds, each grain repreſents a pound and a fraction of a pound; and hence ſome difficulty and confuſion ariſe in making the ſubdiviſions. A better method is that of Mr Hellot, which is to make the fictitious or eſſay quintal equal to a hundred real grains, and then each grain repreſents a real pound. This eſſay quintal is ſufficiently exact for ores of lead, tin, copper, iron, antimony, biſmuth, and mercury. But for ores of ſilver and gold another repreſentation is convenient; for theſe metals, as Mr. Hellot ſays, are generally in ſo ſmall quantity, that the button or ſmall piece of metal obtained in the eſſay could not be accurately weighed, if a hundred real grains were made to repreſent a quintal; and the difficulty of ſeparating the gold from ſo ſmall a quantity would be ſtill greater. Theſe motives have induced Mr. Hellot to uſe for theſe ores a fictitious quintal ſixteen times bigger, that is, equal to 1600 real grains, which repreſent 1600 ounces, that is, 100 lb. or quintal. The ounce being repreſented by a grain, its ſeveral ſubdiviſions muſt be repreſented by fractions of a grain. Thus

Thus 12 grains of the fictitious quintal correspond with $\frac{5}{48}$ of a real grain *(m)*; and this latter quantity may be accurately weighed in essay ballances, which when well made, are sensible to a much less weight.

When a quintal of an ore to be essayed has been weighed, and lotted, as we described above, it is to be roasted in a test under a muffle. It is to be washed, if necessary; and, in short, the same operations are to be made in small which are usually done in great. Additions also are to be made, and in proper proportions, according to the peculiar nature of the ore. The fluxes generally mixed with the ore in essays are three, four, or five parts of black flux; one, two, or three parts of calcined borax; and one half of that quantity of decrepitated common salt. The more refractory the ore is, the more necessary is the addition of these fluxes: then the whole mixture is to be fused either in a forge, or in a melting or essay furnace.

To make essays well, all possible attention and accuracy are to be employed. This object cannot be too much attended to; for the least inaccuracy in weighing, or loss of the smallest quantity of matter, might cause errors, so much greater, as the disproportion betwixt the weights employed and those represented is greater. The most minute accuracy therefore is necessary in these operations. For instance, the essay ballances ought to be small, and exceedingly just. The ore ought not to be weighed till it has been reduced to gross powder fit for roasting; because some of it is always lost in this pulverization. When the ore is roasted, it ought to be covered with an inverted test; because most ores are apt to crackle and disperse, when first heated. To make the fusion good and compleat, the precise degree of fire which is requisite ought to be employed; and when it is finished, the crucible ought to be struck two or three times with some instrument to facilitate the disengagement of the parts of the regulus from the scoria, and to occasion their descent and union into one button of metal. The crucible ought not to be broken, nor its contents examined till it is perfectly cold.

Upon breaking the crucible, we may know that the fusion has been good, if the scoria be neat, compact, and equal; if it has not overflowed or penetrated the crucible; if it contain no metallic grains; and if its surface be smooth, and hollowed in the middle. The regulus or button ought to be well collected, without holes, or bubbles, and to have a neat convex surface; it is then to be separated from the scoria, well scraped and cleaned; and, lastly, is to be weighed. If the operation has been well made, its weight shows the quantity of metal which every real quintal of ore will yield in the great. If the perfect success of this essay be in any respect doubtful, it ought to be repeated; but the best method at all times is to make several essays of the same ore. Some small differences are always found, however well the essays may have been made. By taking the medium of the results of the several operations, we may approach, as nearly as possible, the true product of the ore.

Lastly, as mines are not worked, nor founderies established (which cannot be done without considerable expence) till the ore has been essayed, ten or twelve

(m) The pounds, of which a hundred are here supposed to make a quintal, are called Paris pounds, one of which contains 9216 troy grains. See WEIGHT.

real pounds of the ore ought to be previously essayed; and essayers ought to be furnished with necessary furnaces and instruments for these larger essays.

We now proceed to give some examples of essays of ores. To essay a lead ore, for instance, which is not very refractory, let one or more quintals of this ore be grossly powdered, and roasted in a test till no more sulphureous vapors be exhaled, and then reduced to a finer powder; it is then to be accurately mixed with twice its weight of black flux, a fourth part of its weight of clean filings of iron and of borax. These proportions are given by Mr. Cramer. The mixture is to be put into a good crucible, or rather into a test; it is then to be covered with a thickness of two or three fingers of decrepitated sea-salt; the crucible is to be closed, and placed in a melting furnace, which is to be filled with unlighted charcoal, so that the top of the crucible shall be covered with it. Lighted coals are then to be thrown upon the unkindled charcoal, and the whole is left to kindle slowly, till the crucible be red-hot; soon after which a hissing noise proceeds from the crucible, which is occasioned by the reduction of the lead: the same degree of fire is to be maintained while this noise continues; and is afterwards to be suddenly encreased, so as to make a perfect fusion; in which state it is to be continued during a quarter of an hour; after which it is to be extinguished; and the operation is then finished.

The filings of iron are added to the mixture, to absorb the sulphur, a certain quantity of which generally remains united with the lead ore, notwithstanding the roasting. We need not fear lest this metal should unite with the lead and alter its purity; because although the sulphur should not hinder it, these two metals cannot be united. The refractory quality of the iron does not impede the fusion; for the union it forms with the sulphur renders it so fusible, that it becomes itself a kind of flux.

This addition of iron in the essay of lead ores would be useless, if the ores were sufficiently roasted, so that no sulphur should remain.

Lead ores generally contain some silver, and sometimes a considerable quantity of it; wherefore, after the ore has been essayed, and the regulus of lead collected and weighed, it ought to be tested, to discover the quantity of silver it contains; and as sometimes these lead ores contain also gold, the button of silver remaining upon the cupel ought to be essayed by parting, to ascertain the quantity of gold, if there be any.

The details for the essays of all other ores and minerals are too numerous to be inserted in this work. They are themselves the subject of several books, which may be consulted. The best of these books are Cramer's Art of Essaying, (*Ars Docimastica*), and Schlutter's Work translated into French by Mr. Hellot. We shall find many things relating to this matter under the articles, ORES, SMELTING *of* ORES. (*n*)

(*n*) The essaying of ores is a matter of such importance to chemistry, to arts, and to the wealth of nations, that we shall endeavor to supply what the author of the Dictionary has omitted on this subject, by adding to the several articles of the ores of metals the methods of essaying these ores. *See* ORES. We shall here only observe in general, that the methods generally practised for essay ores of imperfect metals, and semimetals especially, are insufficient to procure the whole quantity of metal contained in ores, or even so much as is obtained in the smelting of large quantities of ores; and that therefore the result of essays is not to be considered as the precise quantity contained in an ore, but generally

CCLXXI. ESSAY *of the* VALUE *of* SILVER, to examine its purity, or the quantity of alloy mixed with it. The common method of examining the purity of silver, is by mixing it with a quantity of lead proportionable to the quantity of imperfect metals with which it is supposed to be alloyed; by testing this mixture; and afterwards by weighing the remaining button of silver. The loss of weight which the silver suffers by cupellation shews the quantity of imperfect metals which it contained.

We may hence perceive, that the essay of silver is nothing else than the refining of it by cupellation. The only difference betwixt these two operations is, that when silver is tested merely for the purpose of refining it, its value is generally known; and it is therefore mixed with the due proportion of lead, and tested without any necessity of attending to the loss of weight it sustains during the operation; whereas in the essay all possible methods ought to be employed to ascertain precisely this loss of weight. The first of these operations, or the mere refining of silver, is made in the great, in the smelting of silver ores, and in mints for making money. *See* REFINING. The second operation is never made but in small; because the expences of small operations are less than of great, and the requisite accuracy is more easily attended to. The last operation is our present subject, and is to be performed in the following manner.

We suppose, first, that the mass or ingot of silver, of which an essay is to be made, consists of twelve parts perfectly equal, and these twelve parts are called penny-weights. Thus if the ingot of silver be an ounce weight, each of these twelve parts will be $\frac{1}{12}$ of an ounce; or if it be a mark, each of these will be $\frac{1}{12}$ of a mark, &c. Hence if the mass of silver be free from all allay, it is called silver of twelve penny-weights; if it contains $\frac{1}{12}$ of its weight of allay, it is called silver of eleven penny-weights; if $\frac{2}{12}$ of its weight be allay, it is called silver of ten penny-weights; and these ten penny-weights or parts of pure silver are called *fine penny-weights*.

We ought to observe here concerning these penny-weights, that essayers give also the name *penny-weight* to a weight equal to twenty-four real grains; which latter real penny-weight must not be confounded with the former, which is only ideal and proportional; and such a confusion is the more likely to take place, as this

generally only as an inaccurate approximation to that quantity. Mr. Gellert ascribes one cause of the want of success of these operations to the alkaline salts employed as fluxes to the ores, by which most metallic calxes are partially soluble, but more especially so, when any of the sulphur of the ore remains; which, by uniting with these salts, forms a hepar of sulphur, which is the most powerful of all solvents. He proposes therefore to omit the black flux, and other alkaline salts, and to add nothing to the ore but powder of charcoal, and some fusible glass. This method, he says, he learned from Mr. Cramer, and has himself used with much success in the essays of iron and copper: but finding that other imperfect metallic substances could not sustain the heat necessary to effect the fusion and vitrification of the unmetallic parts of the ore without being partly dissipated, he found it necessary to add in the essays of these latter metallic matters some borax, by which the fusion might be completed with less heat. As we consider this as a considerable improvement in the art of essaying ores, we shall, to the articles of the several ores, add not only the processes commonly prescribed, but also these of Mr. Gellert, according to the method here mentioned. I have sometimes essayed ores very successfully by this method, from which I could obtain little, if any metal, by means of the black flux. *See* ORES.

ideal penny-weight is alfo, like the former, divided into twenty-four ideal grains, which are called *fine grains.*

An ingot of fine filver, or filver of twelve penny-weights, contains then 288 fine grains; if this ingot contains $\frac{1}{288}$ part of allay, it is faid to be filver of eleven penny-weight and twenty-three grains; if it contains $\frac{2}{288}$ of allay, it is called filver of eleven penny-weight and twenty-two grains; if it contains $\frac{14}{288}$, it is called filver of eleven penny-weight and ten grains; and fo on. Laftly, the fine grain has alfo its fractions, as $\frac{1}{2}$, $\frac{1}{4}$ of a grain, &c.

As effays to difcover the value of filver are always made in fmall, effayers only take a fmall portion of an ingot for the trial, and the cuftom in France is to take thirty-fix real grains for this purpofe, which is confequently the largeft weight they employ, and reprefents twelve fine penny-weights. This weight is fubdivided into a fufficient number of other fmaller weights, which alfo reprefent fractions of fine penny-weights and grains. Thus eighteen real grains, which is half of the quantity employed, reprefent fix fine penny-weights; three real grains reprefent one fine penny-weight, or twenty-four fine grains; a real grain and a half reprefent twelve fine grains; and $\frac{1}{32}$ part of a real grain reprefents $\frac{1}{4}$ part of a fine grain, which is only $\frac{1}{1152}$ part of a mafs of twelve penny-weights.

We may eafily perceive that weights fo fmall, and effay balances, ought to be exceedingly accurate. Thefe balances are very fmall, fufpended and inclofed in a box the fides of which are panes of glafs, that they may be preferved from duft, and that their motion may not be affected by agitated air, fo as to diforder their action.

When an effay of a mafs or ingot of filver is to be made, the cuftom is to make a double effay. For this purpofe, two fictitious femi-marks, each of which may be equal to thirty-fix real grains, are to be cut from the ingot. Thefe two portions of filver ought to be weighed very exactly; and they ought alfo to have been taken from oppofite fides of the ingot.

Perfons accuftomed to thefe operations know pretty nearly the value of filver merely by the look of the ingot, and ftill better by rubbing it on a touchftone. By the judgment they form of the purity of the ingot, they regulate the quantity of lead which is to be added to it, as this quantity muft be always proportionable to the quantity of imperfect metal mixed with the filver.

Neverthelefs, this proportion of lead to the alloy has not been precifely determined. Authors who treat of this fubject differ much. They who direct the largeft quantity of lead fay, that thereby the alloy is more certainly deftroyed; and others who direct a fmall quantity of lead pretend, that no more of that metal ought to be ufed than is abfolutely neceffary, becaufe it carries off with it always fome portion of filver. Every effayer ufes his own particular method of proceeding, to which he is attached.

To afcertain thefe doubtful points, three chemifts of the Academy of Sciences at Paris, Meffrs. Hellot, Tillet, and Macquer, were appointed by the French Government. They were directed to afcertain every thing concerning the effay of gold and of filver by authenticated experiments, made under the infpection of a minifter whofe fuperior knowledge is equal to his defire of public good, and in prefence of the officers of the mint.

It appeared that the beft proportions were, to add from two to three parts of lead to one part of filver of eleven penny-weights, and twenty-three grains value,

value, that is, which contains $\frac{1}{288}$ of alloy; from four to six parts of lead to one part of silver of eleven penny-weight, twelve grains value, or which contains $\frac{1}{24}$ of alloy, which is nearly the value of silver employed for plate; from six to eight parts to one part of silver of eleven penny-weight, which contains $\frac{1}{12}$ of alloy, such as that of silver coin; and so on in proportion. *(o)*

Two cupels of equal size and weight are to be chosen. The custom is to use cupels of such a size that their weight shall be equal to that of one half of the lead employed in the essay; because such cupels have been found capable of imbibing all the litharge formed during the operation. These cupels are to be placed together under a muffle in an essay-furnace. The fire is to be kindled, and the cupels to be made red-hot, and to be kept so during half an hour at least before any metal be put into them. This precaution is necessary to dry and calcine them perfectly; because if they contained any moisture or inflammable matter, an ebullition and effervescence would be occasioned in the essay. When the cupels are heated so as to become almost white, the lead is to be put into them; the fire is to be encreased, which is done by opening the door of the ash-hole so as to admit air, till the lead becomes red, smoking, and is agitated by a motion of its parts called its *circulation*, and till its surface becomes smooth and clear.

Then the silver previously beat into small plates, for its easier fusion, is to be put into the cupels; the fire is to be continued, and even encreased, by putting hot coals at the mouth of the muffle, till the silver shall have *entered the lead*, that is, till it have melted and mixed with the lead. When the melted matter circulates well, the heat is to be diminished by taking away, partly or entirely, the coals put at the mouth of the muffle, and by closing more or less the doors of the furnace.

The heat ought to be regulated so, that the essays in the cupels shall have surfaces sensibly convex, and shall appear ardent, while the cupels are less red; that the smoke shall rise almost to the roof of the muffle; that undulations shall be made in all directions upon the surfaces of the essays, which are called *circulations*; that their middles shall be smooth and surrounded with a small circle of litharge, which is continually imbibed by the cupels.

The essays are to be kept in this state till the operation is finished, that is, till the lead and alloy have soaked into the cupel; and the surfaces of the buttons of silver being no longer covered with a pellicle of litharge, become

(o) The imperfect metals are destructible by scorification with lead; but when they are allayed with silver or gold, a larger quantity of lead is required to produce the scorification of any given quantity of imperfect metals, than when they are not allayed and defended from the action of the lead and fire by mixture with the perfect metals. And further, the quantity of lead requisite for this purpose must be encreased, when the quantity of silver or gold, with which the given quantity of imperfect metal is allayed, is encreased. Thus, for instance, an ounce of pure copper may be consumed by sixteen ounces of lead. But if an ounce of copper be allayed with eight ounces of silver, about six times the above quantity of lead, or ninety-six ounces, will be required to destroy the ounce of copper; and if the ounce of copper be mixed with thirty-six times its weight of silver, its scorification will require 128 ounces of lead. The quantity of lead must be still further encreased for another reason, namely, that almost all lead, as Cramer says, contains some portion of copper.

ſuddenly bright and ſhining, and are then ſaid to *lighten*. If the operation has been well conducted, the two eſſays ought to become bright nearly at the ſame time. When the ſilver has been by this operation well refined, we may ſee, immediately after it has brightened, the ſurface of the ſilver covered with rainbow colors, which quickly undulate and croſs each other, and then the buttons become fixed or ſolid.

The management of the fire is an important article in eſſays. For if the heat be too great, the lead is ſcorified and imbibed by the cupel ſo quickly, that it has not ſufficient time to ſcorify and carry along with it all the alloy ; and if the heat be too little, the litharge is gathered upon the ſurface, and does not penetrate the cupel. The eſſayers ſay then that the eſſay is *choaked* or *drowned*. In this caſe the eſſay does not advance, becauſe the litharge covering the ſurface of the metal defends it from the contact of air, which is abſolutely neceſſary for the calcination of metals. *See* CALCINATION *and* COMBUSTION.

We have above related the marks of a ſucceſsful eſſay. The heat may be known to be too great, from the convexity of the ſurface of the melted metal ; from a too ſtrong circulation ; from the too vivid appearance of the cupel, ſo that the colors given to it by the litharge cannot be diſtinguiſhed ; and laſtly, by the ſmoke riſing up to the roof of the muffle, or not being at all viſible, from its being ſo ardent and red-hot as not to be diſtinguiſhable. In this caſe the heat muſt be diminiſhed by ſhutting the door of the aſh-hole : Some eſſayers, for this purpoſe, put round the cupels ſmall, oblong, cold pieces of baked clay, which they call *inſtruments*.

If on the contrary, the melted metal have a ſurface not very ſpherical, relatively to its extent ; if the cupel appear dark colored, and the ſmoke of the eſſay do only creep upon the ſurface ; if the circulation be too weak, and the ſcoria which appears like bright drops have but a dull motion, and are not ſoaked into the cupel ; we may be aſſured that the heat is too weak ; much more may we be aſſured of it when the metal *fixes*, as the eſſayers call it. In this caſe, the fire ought to be encreaſed by opening the door of the aſh-hole, and by placing large burning coals at the mouth of the muffle, or even by laying them acroſs upon the cupels.

As ſoon as the lead is put into the cupels, the fire is to be encreaſed, becauſe they are then cooled by the cold metal, and the lead ought to be quickly melted, to prevent its calx from collecting upon its ſurface in too great quantity before it be formed into litharge ; which it would do, and be difficultly fuſed, if the heat were too weak.

When the ſilver is added to the lead, the heat muſt be ſtill encreaſed, not only becauſe the ſilver cools the maſs, but becauſe it is leſs fuſible than lead. And as all theſe effects ought to be produced as quickly as poſſible, more heat is at length given than ought to be continued ; and therefore, when the ſilver has entered the lead, the heat is to be diminiſhed till it becomes of a due intenſity for the operation.

During the operation the heat ought gradually to be augmented to the end of it, both becauſe the metallic mixture becomes leſs fuſible as the quantity of lead diminiſhes, and alſo becauſe the lead is more difficultly ſcorifiable, as it

is united with a larger proportion of ſilver. Hence the eſſays muſt be rendered very hot before they brighten.

When the operation is finiſhed, the cupels are left in the ſame heat during ſome ſeconds, to give time to the laſt portions of litharge to be entirely abſorbed; becauſe if any of it remained under the buttons of ſilver, it would ſtick to them. The fire is then allowed to extinguiſh, and the cupels to cool gradually, till the buttons have entirely fixed, particularly if they be pretty large; becauſe if they cool too quickly, their ſurfaces fix and contract before the internal maſs, which is thereby ſo ſtrongly compreſſed as to burſt through the external ſolid coat and form vegetations, or even to be entirely detached from the reſt of the maſs and diſſipated. This is called *the vegetation of the button.* It ought to be carefully prevented, becauſe ſmall bits of ſilver are ſometimes thrown out of the cupel.

Laſtly, when the buttons are thoroughly fixed, they are to be diſengaged from the cupels by a ſmall iron utenſil while they are yet hot, otherwiſe they could not be diſengaged clean and free from part of the cupels which ſtrongly adhere to them when the heat is much diminiſhed.

Nothing then remains to compleat the eſſay but to weigh the buttons. The diminution of weight which they have ſuſtained by cupellation will ſhow the purity or value of the ingot of ſilver.

We ought to obſerve, that as almoſt all lead naturally contains ſilver, and that after cupellation this ſilver is mixed with the ſilver of the ingot in the button of the eſſay; before we employ any lead in this operation, we ought to know how much ſilver it contains, that we may ſubtract this quantity from the weight of the button, when we compute the fineneſs of the ſilver of the ingot eſſayed. For this purpoſe eſſayers generally cupel a certain quantity of their lead ſeparately, and weigh accurately the button of ſilver it yields: or, at the ſame time when they eſſay ſilver, they put into a third cupel, in the muffle, a quantity of lead equal to that employed in both their eſſays; and when the operation is finiſhed, and the buttons are to be weighed, they throw the ſmall button produced from the lead alone into the ſcale which contains the weights; and as this exactly counterpoiſes the ſmall portion of ſilver which the eſſay buttons have received from the lead employed in the cupellation, the weights will ſhew preciſely the quantity of ſilver contained in the ingot, and thus the trouble of calculating is prevented. The ſmall button of ſilver procured from the cupellation of lead alone is called the *witneſs.* But to prevent this trouble, eſſayers generally employ lead which contains no ſilver, ſuch as that from Willach in Carinthia, which is therefore procured by eſſayers.

In the ſecond place we ſhall obſerve, that a certain quantity of ſilver always paſſes into the cupel, as refiners in the great have long obſerved, and which happens alſo in eſſaying ſmall quantities. The quantity of ſilver thus abſorbed, varies according to the quantity of the lead employed, and the matter and form of the cupels; all which objects will undoubtedly be determined by the above-mentioned chemiſts.

The cupellation which we have now deſcribed is exactly the ſame for eſſays, by which the produce of a ſilver ore, or of an ore of another metal containing ſilver, is determined. But as theſe ores contain frequently gold, and ſometimes

in considerable quantity, when these essays are made, the buttons of silver obtained by the essays ought to be subjected to the operation called *parting*. *See* Silver, Refining, Furnace (Essay), Muffle, *and* Cupel.

CCLXXII. ESSAY *of the* VALUE *of* GOLD. The fictitious weights used to determine the purity of gold, and to essay this metal, are different from those of silver. *See the preceding article.* A mass of gold perfectly pure, or which contains no alloy, is ideally divided into 24 parts, called *carats*; this pure gold is therefore called gold of 24 carats. If the mass or ingot contain $\frac{1}{24}$ part of its weight of alloy, the gold is then of 23 carats; and if it contains $\frac{2}{24}$ or $\frac{1}{12}$ of alloy, it is gold of 22 carats, &c. Hence we see that the carat of gold is only a relative and proportional weight, so that the real weight of the carat varies according to the total weight of the mass of gold to be examined. If this mass of gold weighs a mark, the real weight of the carat will be $\frac{1}{24}$ of eight ounces, which is equal to a mark. If the mass weigh an ounce, the carat will be $\frac{1}{24}$ part of an ounce, or 24 grains. If it is only a penny-weight or 24 grains, the real weight of a carat will be one grain; and so on.

For greater accuracy, the carat of gold is divided into 32 parts, which are relative and proportional weights, as the carat itself is. Thus $\frac{1}{32}$ of a carat of gold is $\frac{1}{32}$ of $\frac{1}{24}$, or the $\frac{1}{768}$ of any mass of gold; and the gold which contains an alloy equal to the $\frac{1}{768}$ part of the whole mass is called gold of 23 carats and $\frac{31}{32}$; gold which contains $\frac{2}{768}$ of alloy is gold of 23 carats and $\frac{30}{32}$; and so on.

The real weight now generally used in the operation for determining the purity of gold, is six grains. This weight then represents 24 carats. The half of this weight, or three real grains, represents 12 carats. According to this progression, we shall find that $\frac{1}{4}$ of a real grain represents one carat, and the $\frac{1}{128}$ parts of a grain represents the $\frac{1}{32}$ of a carat, or the $\frac{1}{768}$ part of a mass of gold to be essayed.

As these weights are exceedingly small, some essayers employ a weight of 12 grains, which must be very convenient.

When a mass or ingot of gold is to be essayed, six grains are to be cut off, and exactly weighed: also 18 grains of fine silver are to be weighed. These two metals are to be cupelled together with about ten times as much lead as the weight of the gold. This cupellation is conducted precisely like that of the essay to determine the purity of silver, excepting that the heat must be raised a little more towards the end of the operation when the essay is going to brighten. Then the gold is freed from all alloy but silver. If the quantity of copper or other alloy destructible by cupellation be required to be known, the remaining button is accurately weighed. The diminution of weight from the sum of the weights of the gold and of the silver determines the quantity of this alloy.

The button containing gold and silver is then to be flattened upon a polished piece of steel, and care must be taken to anneal it from time to time, to prevent its splitting and cracking. By this method it is reduced to a thin plate, which is to be rolled up, in order to be parted by aqua fortis. *See the word* Parting. The diminution found after the parting from the original weight

of

of the gold eſſayed, ſhews the whole quantity of alloy contained in that gold.

The eſſay for determining the purity of gold is then made by two operations: the firſt, which is cupellation, deprives it of all its imperfect metals; and the ſecond, which is parting, ſeparates all the ſilver from it. By antimony alſo gold may be purified, which is a kind of dry parting. By this ſingle operation, all the imperfect metals, and ſilver with which gold is allayed, are ſeparated. *See* PURIFICATION *of* GOLD *by* ANTIMONY. *See alſo* GOLD, SILVER, REFINING, ESSAY *to* DETERMINE *the* PURITY *of* SILVER.

CCLXXIII. ESSENCES. Eſſential oils are ſometimes called *eſſences*. Thus we ſay, eſſence of cinnamon, of turpentine, &c. to denote the eſſential oils of theſe ſubſtances. *See* OILS (ESSENTIAL).

CCLXXIV. ETHER. Ether is a white, tranſparent liquor, of a peculiar and penetrating ſmell. Ether is very volatile: it may be entirely diſtilled without leaving any reſiduum, or ſuffering any decompoſition or alteration. It is more volatile and inflammable than rectified ſpirit of wine. Its flame reſembles the flame of ſpirit of wine; but it is ſenſibly much greater, whiter, and more luminous. It is alſo accompanied with a ſlight ſmoke or ſoot, which ſpirit of wine is not.

Ether does not mix with water, as ſpirit of wine does, in all proportions; but ten parts of water are required to diſſolve one part of ether. This liquor has alſo a power of acting upon all oily and fat ſubſtances.

From theſe eſſential properties ether appears to be a ſubſtance exactly intermediate betwixt ardent ſpirits and oils, as has been proved in the elements of chemiſtry. *See* SPIRIT (ARDENT), *and* OIL.

Ether has been but lately known by chemiſts. From certain paſſages indeed of ſome old chemical books, we may infer that ether was not entirely unknown to their authors; but they have not mentioned it diſtinctly, nor have they ſufficiently deſcribed its properties, or the manner of making it: wherefore no attention was given to it, till the curioſity of chemiſts was excited by a publication in the Philoſophical Tranſactions for the year 1730, by a German who calls himſelf Frobenius, (which however is ſuppoſed to be a feigned name) in which he relates the experiments he had made on that liquor, to which he firſt gave the name *ether*. Since that time, many chemiſts have made experiments on this matter. At firſt they made ether difficultly and in ſmall quantities, and at length abundantly and eaſily; particularly ſince Mr. Hellot communicated to ſeveral artiſts a proceſs which he received from a foreign chemiſt. This proceſs has been printed in the Encyclopedia, with conſent of Mr. Hellot.

Since that time, Mr. Beaumé has operated more than any other chemiſt on ether. He has publiſhed the details of his experiments and reſearches, not only upon ether, but upon all the other ſubſtances produced from a combination of ſpirit of wine with vitriolic acid. This forms the completeſt treatiſe on this ſubject which has hitherto been publiſhed.

Vitriolic acid is not the only acid from the mixture of which with ſpirit of wine ether may be produced. The nitrous, marine, and acetous acids have alſo been found capable of forming, with ſpirit of wine, liquors poſſeſſed

of all the essential properties of ether; but differing from ether, properly so called, or vitriolic ether, by properties peculiar to each. We shall speak successively of these different ethers, beginning with the vitriolic, called simply *ether*, because it is the chief one and the first discovered. The following process for making this ether, which is the best hitherto published, is extracted from Mr. Beaumé's dissertation.

Put two pounds of perfectly rectified spirit of wine into a glass retort, and pour upon it at once two pounds of well concentrated vitriolic acid.

This acid being much heavier than the spirit of wine, sinks directly to the bottom, and does not mix with the spirit of wine. Shake the retort gently, and repeatedly, that the two liquors may mix. The mixture will boil, and become very hot. Vapors will issue from it with a loud hissing noise, and a sweet penetrating smell. The mixture will then assume a yellow-reddish color. Place the retort in a sand-bath, warmed by degrees to the same heat with itself. Lute to it a receiver, in the side of which is a small hole, and distill the mixture by a heat sufficiently intense to make it quickly boil and to keep it boiling. At first a very sweet spirit of wine will pass into the receiver, after which the ether will come, which may be distinguished by striæ formed on the upper part and neck of the retort. Continue the distillation with the same degree of fire, and from time to time unstop the small hole of the receiver, till you perceive, upon applying your nose near this small hole, a suffocating smell of volatile sulphureous acid. Then the receiver ought to be unluted; and the contained liquor, which will be nearly eighteen ounces, must be quickly poured into a glass bottle, which ought to be well stopped. This liquor is a mixture of a very dephlegmated part of the spirit of wine, of a sweet penetrating smell, which passes at first; of ether, which was formed during the distillation; of a little oil; and sometimes also of a small quantity of sulphureous acid; both which substances pass frequently with the last portions of the ether, particularly if the distillation has been too long continued. To separate the ether from these other substances, put the whole mixture into a glass retort, with a little deliquiated fixed alkali, to absorb and retain the sulphureous acid, and distill very slowly in a sand-bath, with a very gentle lamp heat, till you have made one half of the liquor pass over. The liquor that rises in this distillation, called also *rectification*, is ether. (*p*)

Before the Count de Lauraguais had discovered that ether was miscible with water in a certain proportion, the custom was to put the ether after this distillation into a phial with distilled water and to shake together these two liquors. The ether rose quickly to the surface, and floated on the water; from which it might be separated by a funnel, as oil may from water, and obtained unmixed. But this is evidently bad management: for in the first

(*p*) Mr. Beaumé says, that by distilling together six pounds of concentrated vitriolic acid with an equal quantity of highly rectified spirit of wine, about six ounces of aromatic spirit of wine will be first distilled, and then some ether. By continuing a heat sufficient to make the liquor boil, white vapors of a volatile, sulphureous smell, together with some ether, will rise; and thus in 15 or 16 hours, about three pounds and a half of liquor will have passed into the receiver. If another receiver be adapted to the retort; by continuing the distillation, from ten to sixteen ounces of volatile sulphureous spirit will

place, the water thus mixed dissolves about one tenth part of its weight of ether before it is saturated, a which is lost; and in the second place, for the same reason that water dissolves some ether, the ether also dissolves a certain quantity of water, by which it is weakened, and its properties altered, as Mr. Beaumé has observed.

The production of ether is one of the most beautiful and instructive phenomena of chemistry. Spirit of wine, which is at once inflammable, and miscible with water in all proportions, differs from any oil by containing a more considerable quantity of water, which enters its composition as a principle or constituent part. This being established, if we deprive spirit of wine of part of that aqueous principle by which it differs from oils, it ought to assume the characters of oil, and to approach so much more to an oily nature, as it has been deprived of a greater quantity of the watery principle which constitutes it spirit of wine and by which it differs from oil. But this is precisely what happens to it in the production of ether, and in the analysis of the remaining mixture after the formation of ether.

Concentrated vitriolic acid having a power of attracting water strongly, does, when mixed with spirit of wine, accordingly at first unite with the water which [illegible] spirit of wine may contain superabundantly: and its action would not ex- [illegible] ther, and it would not separate the watery principle from the spirit of wine, if heat were not applied sufficient for distillation; for ether cannot be obtained from this mixture but by distillation. But when by the distilling heat the power of the vitriolic acid to attract water is encreased, that acid then becomes capable of separating the watery principle of the spirit of wine and of uniting with it.

As this is done gradually, so the spirit of wine which rises in distillation ought to be more and more changed by the action of the vitriolic acid.

will pass over, and from two to four gros * of oil. By distilling the liquor in the first receiver, together with a small quantity of oil of tartar, by a very gentle heat of a lamp furnace, about two pounds and four ounces of pure ether may be obtained; and afterward when a new receiver is adapted, and a stronger heat applied, from eight to ten ounces of aromatic liquor, which makes a good anodyne mineral liquor of Hoffman, will be distilled. The ether which is first distilled is the purest, and that which passes afterwards has a smell of the oil of wine, improperly called sweet oil of vitriol, and of the volatile sulphureous acid. To obtain the largest possible quantity of ether, and free from the other liquors which are distilled in this operation, are the chief objects of attention: and, considering how much more volatile ether is than any of the liquors which affect its purity, we have reason to believe, that a larger quantity, and a purer ether than is procured by the ordinary process, might be obtained by using an apparatus for the distillation and rectification, so contrived, that vents of different heights from the retort or matrass shall be given to the vapors of the different degrees of volatility, to each of which vents a receiver shall be adapted; so that none but the purest ether can be found in the receiver communicating with the highest vent, and the ether which happens to be mixed with the other liquors in the receivers communicating with the inferior vents may be again rectified with less heat, till the whole quantity of pure ether be thus collected.

* A gros is equal to 72 grains.

This accordingly happens; and very distinctly. The first liquor which rises in this distillation is a portion of spirit of wine, very volatile, penetrating, and dephlegmated; but which has not been deprived of its watery principle, and therefore retains the essential properties of spirit of wine.

The liquor which rises next is spirit of wine, deprived of part of its watery principle by vitriolic acid. It consequently is spirit of wine essentially altered, and approximated to the nature of oil, in proportion to the quantity of watery principle which it has lost. This is ether, which differs from spirit of wine in being no longer miscible with water in all proportions, and in emitting a whiter and more brilliant flame, accompanied with some fuliginous smoke.

These properties by which ether differs from spirit of wine characterize so well its oily nature, that most chemists consider this liquor as a very volatile oil. It seems, however, to be rather an intermediate substance betwixt oil and spirit of wine. The solubility of ether by water makes us chiefly consider it in this light; for what oil, properly so called, can be dissolved by water as ether can?

If the distillation of the mixture be continued after the ether has risen, the vitriolic acid, still continuing its action upon the spirit of wine already altered, takes at length from it all the watery principle by which it differs from a true oil, and hence ought to leave it in the state of oil. Accordingly, after the ether has passed over in distillation, an oil rises which wants none of the essential properties of true oil, as it is not miscible with water, burns with a fuliginous smoke, leaves a resinous coal, &c. This oil, thus created in some measure during the operation, is known by the name improperly given to it, of *Sweet Oil of Vitriol.*

From all this we might infer, that if ether ready prepared were mixed and distilled with concentrated vitriolic acid, it ought to be changed and transformed into sweet oil of vitriol. Accordingly Mr. Beaumé observed, that this did happen in an experiment he made, an account of which is given in his Dissertation on Ether.

When the sweet oil of vitriol is distilling, the vitriolic acid acts also upon the phlogiston of the remaining part of the spirit of wine, and unites with one part of the inflammable principle. Hence we may see at the same time much
sulphureous, volatile, suffoc [illegible] But as the vitriolic
acid which forms it then becomes c [illegible] it has taken
from the spirit of wine, this first s [illegible] acid, although very quick and
penetrating, is very aqueous, and has not [illegible]

By continuing this distillation, with a g [illegible]
of this sulphureous acid is raised, which [illegible]
times also a little concrete sulphur is su [illegible]
wards the end of the distillation, at a fixed [illegible]
suppose; for the same substances are [illegible]
ture of any oil with concentrated vitriolic acid. [illegible]

From all that has been said concerning the nature and properties of ether we may conclude, that this substance is nothing else than spirit of wine deprived by vitriolic acid of a part of its aqueous principle, and thereby approximated to the nature of oil. Some chemists believe that vitriolic acid is a constituent part

part of ether. This opinion, although it is not demonſtrated, is not however deſtitute of probability, and deſerves to be examined by experiments. For, on one ſide, a more copious and diſtinct acid is contained in all oils than in ſpirit of wine; and on the other ſide, the particular properties by which ethers formed by the nitrous, marine, and acetous acids differ from vitriolic ether, ſeem to be owing to adhering portions of the acids with which theſe ethers are prepared. This queſtion requires a particular examination.

Ether is not employed in the arts, although it appears capable of being uſefully employed in many caſes, and particularly in the ſolution of certain concrete oily matters for the preparation of varniſhes; but its high price prevents its introduction into the arts.

As ether is the moſt volatile and evaporable of all known liquors, and as in general liquors produce a degree of cold proportionable to the quickneſs of their evaporation, as Mr. Beaumé diſcovered, and ſeveral others have obſerved; therefore a very great degree of artificial cold may be produced by means of ether. Mr. Beaumé has ſunk the mercury of Reaumur's thermometer to 40 degrees below the freezing point, by applying linens ſoaked in ether to the ball containing the mercury; and he makes this fine experiment every year in his courſe of chemiſtry conjointly with Mr. Macquer. (q)

Ether, like all thin and volatile oily matters, has the property of taking gold from aqua regia; but as it is more ſubtle than any other of theſe matters, it produces this effect better. For this purpoſe, ether ought to be poured upon a ſolution of gold in aqua regia, and the two liquors mixed together by ſhaking the containing phial. When this mixture is left to reſt, the ether ſoon diſengages itſelf from the aqua regia, and floats on the ſurface of the acid liquor, which being deprived of its gold is rendered white, while the ether has now acquired a yellow color from the gold it contains. This is an expeditious method of making a tincture of gold, or potable gold. We ought to obſerve that the gold which thus paſſes into the ether ſtill retains a certain quantity of aqua regia.

Ether is employed in medicine. As a very thin and volatile inflammable matter, it acts powerfully on the nervous ſyſtem, like all the matters of this kind. Frederic Hoffman was one of the firſt who employed it as a ſedative and antiſpaſmodic. The famous mineral anodyne liquor of this phyſician is nothing elſe than ſpirit of wine, in which are diſſolved ſome ether and ſweet oil of vitriol. It owes all its medicinal virtues to the ether.

Since ether has become more common and better known, many phyſicians preſcribe it ſingly, in the doſe of ſeven or eight drops upon a bit of ſugar, which is to be eat or to be diſſolved in ſome proper liquor and drank. It is given in flatulent colics, obſtinate hiccups, convulſive, hyſterical affections, and other diſorders of this kind. It certainly produces frequently excellent effects; but, like all other antiſpaſmodic remedies, it ſometimes produces none.

(q) Mr. Amontons, in a Memoir of the Academy of Paris, (1699) and more particularly, M. Richman, in a Memoir of the Academy of Peterſburg, (1747) have obſerved that cold was produced by evaporating fluids. Dr. Cullen diſcovered, that the cold thus produced by evaporating fluids was conſiderably greater in vacuo than in air. *See Eſſays Phyſ. & Liter.* Edinburgh, vol. 2, 1756.

Several perſons have affirmed, that ether applied externally to the back of the neck, or to the temples, diſſipated inſtantaneouſly, and as it were by enchantment, head-achs and meagrims. I have tried it in all doſes upon myſelf for theſe diſorders, but without ſucceſs; but we cannot from thence infer that it may not have better effects upon other perſons. (r)

CCLXXV. ETHER (ACETOUS). Since the diſcovery of the ether deſcribed in the preceding article, chemiſts have endeavoured to obtain ſuch a liquor from ſpirit of wine by means of other acids; and accordingly they produced it firſt by means of the nitrous acid, then by the acetous, and laſtly, by the marine. We ſhall ſpeak ſucceſſively of theſe ſeveral ethers.

The diſcovery of the production of ether by the acetous acid was made by the Count de Lauraguais. This ether is made by mixing together equal parts of rectified ſpirit of wine, and concentrated acid of vinegar obtained by diſtilling cryſtals of copper, called the Spirit of Venus, or radical vinegar. This mixture is to be diſtilled in the manner directed for vitriolic ether, and a conſiderable quantity of a liquor is obtained, which is poſſeſſed of the eſſential qualities of ether, as deſcribed in the former article, but which has alſo ſome of the acidity and peculiar ſmell of radical vinegar.

When this ether is mixed with liquid fixed alkali, and again diſtilled, or rectified by a lamp heat, an acetous ether is obtained free from ſuperabundant acid, and much liker to true ether. It retains, however, the ſmell, not of the acid, but of the inflammable part of vinegar.

We obſerve, that by this proceſs a greater quantity of ether is obtained than by diſtillation with vitriolic acid, which ſhews that the acid of vinegar is eſſentially fitter to produce ether than the vitriolic acid. This difference muſt undoubtedly be attributed to the great quantity of ardent ſpirit, which is one of the principles of the acid of vinegar, and which perhaps already approaches the ſtate of ether. *See* VINEGAR (RADICAL).

As this diſcovery has been but lately made, the properties of the acetous ether, and the phenomena which its reſiduum may afford, have not yet been ſufficiently examined.

CCLXXVI. ETHER (MARINE). The diſcovery of the true proceſs for making ether by means of the marine acid, is the lateſt which has been made on this ſubject. The Marquis de Courtanvaux has communicated his proceſs to the Academy of Sciences.

The difficulty with which marine acid unites in general with inflammable ſubſtances has retarded the diſcovery of marine ether; for no ether can be obtained by treating the moſt concentrated marine acid with ſpirit of wine in the ordinary method, by which the other ethers are procured. Able artiſts, and particularly Mr. Rouelle and Mr. Beaumé, had attempted unſucceſsfully to procure ether by diſtilling ſmoking marine acid with ſpirit of wine. Mr. Beaumé, indeed, in his Diſſertation concerning Ether, had given a proceſs, by which he affirms that he had obtained a ſmall quantity of marine ether. This

(r) Ether diſſolves all eſſential and expreſſed oils, animal empyreumatic oil, reſins, and almoſt entirely ambergriſe. It diſſolves difficultly petroleum and oil of amber. It precipitates regulus of antimony from aqua regia, and ſilver from nitrous acid. It takes ſpots of greaſe from ſilks without affecting their colors.

proceſs

process consists in making the fumes of the marine acid and of the spirit of wine meet together in the same receiver. But the quantity of ether obtained by this method was very small. The process also is troublesome, and even imperfect, as Mr. Beaumé himself declares. He would not have published it in that imperfect state, but because the possibility of the fact had been denied. What he says may be seen in his Dissertation on Ether.

Others, and particularly German chemists, had attempted to employ for this purpose a marine acid which was united with a metallic substance, such as the butter of antimony, and had observed the singular phenomena which happened in these mixtures. The Marquis de Courtanvaux has perfectly succeeded by employing the smoking spirit of Libavius, which is a highly concentrated marine acid, obtained from corrosive sublimate by tin, and impregnated with a considerable quantity of this metal.

This smoking liquor, mixed with an equal part of spirit of wine, and distilled together, easily produces a considerable quantity of a liquor possessed of all the essential properties of ether, and which may be considered as a true marine ether. The tin contained in the spirit of Libavius is separated and precipitated in form of a white powder. This ether, like the others, must be rectified to be obtained in its greatest purity. Some reflections concerning its nature will be found at the end of the following article.

CCLXXVII. ETHER (NITROUS). This ether is obtained by mixing nitrous acid with spirit of wine, but with peculiar circumstances.

In the writings of ancient chemists traces of the nitrous as well as of the other ethers may be found; but these traces are neither clear nor precise. The first person who published a satisfactory account of this liquor, and who shewed the true method of obtaining it, was Mr. Navier, a Physician, at Chalons-sur-Marne, and Correspondent of the Academy of Sciences. His process, which he communicated to the Academy in 1742, is very simple, as it consists only in mixing together spirit of wine and spirit of nitre in a bottle, which is to be exactly closed, and left at rest, till the ether is formed and collected like an oil upon the surface of the liquor. This ether is made, as we see, without distillation.

Since Mr. Navier has published his discovery, other chemists have endeavored to improve the process. A very good process is published in the Encyclopedia, which is attributed to Mr. Rouelle. Mr. Beaumé also has published one in his Dissertation on Ether, which is very accurate, and is the result of many trials and researches. Mr. Beaumé's process is as follows.

Put six ounces of rectified spirit of wine into a bottle made of strong and thick glass, large enough to contain a pound of water. Place this bottle in a bucket of fresh water, which will be still better for the purpose if it has been rendered colder by throwing into it two or three pounds of ice, in small bits. Pour upon the spirit of wine, at four or five times, four ounces of smoking spirit of nitre, so concentrated, that a phial, capable of containing an ounce only of water, shall be capable of containing an ounce and a half of this spirit of nitre; observing, during the whole time of pouring the spirit of nitre, that the spirit of wine be kept in a state of perpetual rotation. As soon as the two liquors are mixed, stop the bottle quickly with a good cork, which must be driven firmly into the neck of the bottle, and covered

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and faſtened with a piece of leather doubled, and bound with packthread. Leave it at reſt in the cold water, which ought to be ſometimes renewed.

Two or three hours afterwards, the liquor loſes ſome of its tranſparency by the interpoſition of many ſmall drops of ether, which are diſengaged throughout the liquor. This ether gradually collects and floats upon the ſurface. Within twenty-four hours the mixture will have become clear; and the ether formed, which will be about two ounces, may be ſeparated. But as more ether will ſtill be produced, the method is to leave it ſeven or eight days before any of it be ſeparated. After this time no more ether is formed. Pierce then the cork with a pointed inſtrument; and a conſiderable quantity of air will eſcape with a hiſſing noiſe, which had diſengaged itſelf during the production of the ether, and which is compreſſed in the bottle. When the air has eſcaped, uncork the bottle, and pour quickly its contents into a glaſs funnel, that the ether may be ſeparated.

The ether will amount to about four ounces, and the reſiduum will weigh five ounces and a half; ſo that half an ounce ſhall have been loſt during the proceſs. This ether ought to be put into a well cloſed cryſtal-glaſs bottle.

Nitrous ether in this ſtate has a ſmell like that of the vitriolic ether, but ſomewhat ſtronger and leſs agreeable. It has a light citron color; and as ſoon as the bottle which contains it is uncorked, it bubbles and effervesces. When the ſtopper is put in looſely into the neck of the bottle, it may be obſerved to riſe and fall alternately, which appearance is occaſioned by vapors eſcaping from the ether. The cauſe of theſe phenomena is a conſiderable quantity of air which remains interpoſed betwixt the parts of ether; for when all this air has been once diſengaged from the ether, theſe phenomena do not happen.

Nitrous ether is not, in this ſtate, pure; as it retains ſome of the acid employed, from which it may be purified by mixing it with ſome fixed alkali, and rectifying it with a lamp-heat. In this rectification, it ſuffers a loſs of nearly one half its quantity.

The properties of this rectified nitrous ether are, that it burns with a more luminous flame than the flame of vitriolic ether; that this flame is accompanied with a more ſenſible quantity of ſoot; that after the ether is burnt, a reſiduum of coal is perceptible; and, laſtly, that if it be evaporated on the ſurface of water in open air, it leaves upon the water ſome oil, as the vitriolic ether does, but in a little larger quantity. In other reſpects, but in theſe which ſhew that the nitrous ether is of a more oily nature than the vitriolic, theſe two ethers are perfectly ſimilar.

The activity and violence with which nitrous acid acts upon the ſpirit of wine is the moſt remarkable circumſtance of this operation. The action of nitrous acid is ſo much ſtronger than that of vitriolic acid upon ſpirit of wine, that equal parts of concentrated nitrous acid and ſpirit of wine cannot be mixed and contained; for notwithſtanding all the precautions that can be taken to moderate the action of theſe two liquors upon each other, they mix with ſo much violence when that proportion is uſed, that the mixture is inſtantly heated almoſt to inflammation, is reduced to vapors, and burſts the veſſels with a terrible exploſion.

In Mr. Beaumé's Diſſertation upon Ether, an account of the trials which he made upon this ſubject, and of the reſulting phenomena, may be ſeen.

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In the second place, when spirit of wine and nitrous acid are mixed in proper proportions, ether may be obtained without distillation; which is peculiar to this acid. The effects peculiar to the nitrous acid, in the preparation of ether, are caused by the action which this acid has, not only on the watery principle, but also on the inflammable principle of the spirit of wine. We have therefore reason to believe that nitrous acid converts spirit of wine into ether, not only by depriving it of its watery principle, but also by acting upon its inflammable principle with which it combines, or to which perhaps it joins its own inflammable principle. This is so true, that nitrous ether may be made with a nitrous acid which does not smoke, and which is, in some measure, saturated with water. For this purpose, a larger proportion of spirit of wine ought to be added. But if nitrous acid converted spirit of wine into ether, merely by depriving it of its watery principle, a diluted acid ought not to have the same effect as a smoking and concentrated acid, particularly as it cannot concentrate itself during the operation, since this is performed without distillation. Besides, as nitrous acid has a greater affinity than any other with the inflammable principle, and contains a greater quantity of it, we ought not to be surprized that nitrous ether is produced without distillation, and more easily than any other.

Marine acid, on the contrary, having the least disposition of all the acids to unite with the inflammable principle, and seeming to contain less of it than any other acid, does therefore produce ether with most difficulty; or, properly speaking, does not produce any ether, when pure, but only when it has been combined with metallic substances, as tin and antimony; part of the phlogiston of which it may have acquired. *See* ETHER (MARINE). It probably becomes more proper to combine with the inflammable principle of the spirit of wine, or to communicate that which it has received, after it has already begun to unite itself with the inflammable principle of metallic matters.

From these considerations we are inclined to believe, that in the production of ether, the acids act at the same time upon the watery and inflammable principles of the spirit of wine, by depriving this spirit of the former, and by combining partly with the latter; or by encreasing its proportion of acid, and thereby approximating it to an oily nature.

All acids, and particularly mineral acids, suffer singular alterations, and even transmutations, when they are distilled to dryness with a sufficient quantity of spirit of wine. Mr. Pott, in his Dissertation on the Vinous Acid of Nitre, says, that this acid by being combined with spirit of wine loses the disagreeable smell peculiar to it, and acquires a penetrating and agreeable smell; that it does not rise in form of red vapors; but that it rises with a less degree of heat than when pure, and that it acts less powerfully on fixed alkalis and absorbent earths. He adds, that by distilling this mixture, oil and a residuous coal may be obtained; and that if nitrous acid previously combined with spirit of wine be saturated with a fixed alkali, a salt is formed which does not detonate like nitre, but burns like an oily salt, without waste of detonation.

Pott reasonably thinks, that this experiment may suggest hints concerning the transmutation of acids, and he believes that the nitrous acid in that experiment

loſes its detonating and other eſſential qualities; becauſe the phlogiſton which enters its compoſition as a principle is joined and confounded with the inflammable matter of the ſpirit of wine. The marine acid ſeems to ſuffer leſs alteration in combining with ſpirit of wine; for Mr. Pott ſays alſo, in his Diſſertation on the Vinous Acid of Salt, that having ſaturated with an alkali ſome marine acid previouſly treated with ſpirit of wine, he obtained a regenerated common ſalt, which poſſeſſed all the eſſential properties of common ſalt. Nevertheleſs, Mr. Pott, having diſtilled to dryneſs the thick matter which remains after the moſt fluid and volatile part had been diſtilled from a mixture of marine acid and ſpirit of wine, obtained a reſiduous black fixed coal; which proves that one part of the acid of ſalt contracts in this experiment a very intimate union with the principles of ſpirit of wine; for the marine acid and ſpirit of wine diſtilled ſingly do certainly not leave any reſiduum.

CCLXXVIII. ETHIOPS (MARTIAL). Martial ethiops is iron divided into exceedingly fine parts by the action of water.

This preparation was introduced into medicine by the younger Lemeri, who called it *ethiops* from its black color. To make ethiops, filings of iron are taken, very clean and free from ruſt, and are put into a glaſs veſſel; on theſe pure water is to be poured, to the height of three or four fingers thickneſs above the filings; the filings are to be frequently ſtirred with a ſpatula, till they become ſo fine a powder, that when agitated they remain long ſuſpended in the water: the water thus rendered turbid by the ſuſpended powder of iron, is to be decanted; and the ſediment which is depoſited is to be dried and ground on a porphyry. This is the martial ethiops.

Iron is a metal which is ſoluble in many menſtruums. Its ſurface is ſenſibly affected by the combined action of air and water, and is in ſome meaſure corroded. It is thereby deprived of part of its inflammable principle, and partly reduced to an earth or calx, called *ruſt*: but to produce this effect, theſe two elements muſt concur; for iron is not ruſted nor altered by expoſure to dry air, or to water alone, without contact of air. (*s*)

Nevertheleſs, the operation of ethiops martial ſhows that water alone, without the concurrence of air, is capable of a certain action upon iron; ſince this metal is by this action, continued ſome time, reduced to parts exceedingly ſmall. Whether this effect is cauſed by ſome heterogeneous particles in the water or in the iron, has not yet been determined. The iron thus reduced into martial ethiops is certainly very different from ruſt. It is black, attractable by magnets, and ſoluble in all acids; which proves that it is not deprived of its inflammable principle. Ruſt, on the contrary, has none of theſe qualities.

Theſe properties of martial ethiops have induced ſome perſons to propoſe it as a remedy much ſuperior to other preparations of iron. This manner of preparing iron for medicinal purpoſes is certainly good and unexceptionable; but

(*s*) Iron is not ſo readily ruſted when kept immerſed in water, as when it is firſt moiſtened and then expoſed to air; but it is nevertheleſs ſubject to ruſt if it be kept a few days under water, as thoſe workmen know who have occaſion frequently to keep pieces of iron under water, to ſoften and render the metal more ductile, and alſo to preſerve the ſurface from ruſt during a ſhort time. When they have occaſion to preſerve iron from ruſt a longer time, they immerſe it in lime-water.

Mr.

Mr. Lemeri certainly ought not to have declaimed againſt all other preparations of iron indiſcriminately, nor to have adviſed their total diſuſe in medicine. He pronounced this general proſcription without ſufficiently underſtanding the matter. He would probably have been more indulgent, if he had known that ſeveral martial ſaffrons, ſuch as thoſe called aperitive, and which are nothing but ruſt, are capable of eaſily reſuming, and by the humid way all the phlogiſton which is neceſſary to reſtore to them all the properties of martial ethiops; and that this change is actually produced upon them when they are taken internally, by the fat matters which they meet in the ſtomach, in the inteſtines, and in the aliments and digeſtive juices. This is proved by the blackneſs of the excrements of thoſe who have taken theſe martial ſaffrons.

Mr. Lemeri had certainly not examined the nature of the precipitates obtained from ſolutions of iron in acids, and particularly in the vitriolic and marine acids, by a phlogiſticated alkali; for he muſt have obſerved that ſuch precipitates receive from the alkali a ſufficient quantity of phlogiſton, to give it a dark and blackiſh color, and to render it ſoluble in any acid: conſequently theſe precipitates, which are at leaſt as fine as the martial ethiops, are alſo equal to it in ſolubility, and preferable from the greater facility of their preparation.

When well phlogiſticated precipitates are required, they ought to be dried in cloſe veſſels, and by diſtillation. This is an operation which is alſo neceſſary for martial ethiops, although the author does not direct it; for the iron, being moiſt and much divided, ruſts with the greateſt facility from the contact of air.

Martial ethiops, and the martial precipitates and ſaffrons above-mentioned, are ſucceſsfully employed in medicine as excellent tonic and fortifying remedies. *See upon this ſubject* IRON.

CCLXXIX. ETHIOPS MINERAL. Ethiops mineral is a combination of mercury with a ſufficiently large quantity of ſulphur. The color of this compound is black, and hence it has been named ethiops.

Ethiops mineral may be made either by fuſion, or by trituration without fuſion.

To make ethiops mineral by fuſion: To ſulphur melted in an unvarniſhed earthen veſſel, an equal quantity of very pure mercury is to be added; the veſſel is at the ſame time to be taken from the fire, and the mixture is to be ſtirred with a ſpatula till it be cold and fixed; the mixture is then become a black and friable maſs, which is to be pounded and ſifted. This is ethiops.

To make this preparation without fire, two parts of mercury are triturated in a glaſs or marble mortar with three parts of flowers of ſulphur, till the mercury no longer appears.

Mercury and ſulphur have a ſtrong diſpoſition to unite together. For this purpoſe, their integrant parts muſt be made to touch, and then they contract an adheſion, but not ſo ſtrong as that which they acquire by ſublimation in the proceſs for making cinnabar.

The black color of ethiops is always taken by mercury, when it is much divided and mixed with inflammable matters. In this reſpect it reſembles ſilver, lead, and other metals, which acquire a black color from the ſuperficial union which they contract with ſulphur or other phlogiſtic matters.

Although the union of mercury with ſulphur in ethiops is not ſo ſtrong as in cinnabar, we muſt not believe that in ethiops theſe two ſubſtances are not united,

but only mixed and interposed; for they really adhere and are combined together. The proof of this is, that they cannot be separated from each other without intermediate substances. These substances are the same as those which are capable of procuring a similar separation by decomposing cinnabar. *See* CINNABAR.

The difference betwixt ethiops prepared by fusion and ethiops prepared by trituration is, that the former contains a less quantity of sulphur than the latter.

Mr. Lemeri has observed, in his Course of Chemistry, that when ethiops is made with fire, one half of the substances employed is lost; but the proportion in which each of the substances is dissipated is not known: we are, however, certain that more sulphur is lost than mercury; notwithstanding which, each kind of ethiops contains more sulphur than is necessary for the saturation of the mercury, as evidently appears from the operation of making artificial cinnabar.

The chief use of ethiops mineral is in medicine. It may be given from six grains to half a dram, incorporated with other suitable remedies. It is employed as a resolvent in the asthma, scrophula, obstructions and diseases proceeding from a stoppage or thickness of humors. Some physicians prescribe it in venereal diseases: others affirm, that ethiops has no medicinal virtue: however, it certainly occasions salivation sometimes, although seldom. *See* MERCURY.

CCLXXX. EVAPORATION. Evaporation is a chemical operation, by which, with a certain degree of heat and access of air, volatile substances are separated from others less volatile.

The effect of evaporation is essentially the same as that of distillation, with this difference, that distillation is almost always employed to separate and collect a volatile substance; whereas evaporation is always employed to separate and collect the fixed or less volatile substance only, the more volatile part being necessarily lost in the operation.

Evaporation is always made in open air, and with open vessels; for air contributes much to the volatilisation of bodies, and evaporation is only performed from their surfaces: hence the general rules for evaporation are, to place the body from which volatile parts are to be evaporated in a flat, shallow, wide vessel, so that it shall present to the air a large surface, towards which even a current of air ought to be directed.

In all evaporations the degree of heat ought to be proportioned to the volatility of the substance to be evaporated, and still more to the degree of fixity of the substance intended to be left, and of its adhesion to the volatile parts. Thus, the less fixed the remaining substance is, and the more strongly it adheres to the volatile substance, the less the heat ought to be. For instance, if we would obtain the portion of oil which is found in spirit of wine and ether, these liquors ought to be evaporated, as Mr. Beaumé did, upon the surface of water in open air, and without any other heat than that of the atmosphere; for, however little the evaporation of these liquors is urged by a heat somewhat too strong, the volatility of this small portion of oil differs so little from that of spirit of wine and of ether, that it would entirely exhale with these liquors without any separation, as it does when they are rectified. Thus Mr. Duhamel having discovered, by his experiments, that the volatile alkali of sal ammoniac carries

carries off with it a considerable portion of the fixed earthy intermediate substances employed to disengage it, could not afterwards separate this earthy part from the concrete volatile alkali, but by allowing this latter to dissipate itself by the heat alone of the air, and by an evaporation which continued several months; because this earthy part, although very fixed, is so well combined, and adheres so strongly to volatile alkali, that it is always carried along with the salt in evaporation, whenever the heat exceeds that of the atmosphere. *See Mr. Duhamel's Memoirs concerning Sal Ammoniac amongst the Memoirs of the Academy.*

On the contrary, in some cases evaporation may be urged by a strong heat, and even by a current of air directed upon the surface of the body. This is practised when the part to be evaporated is not very volatile, and requires considerable heat to raise it, and when the remaining substance is very fixed, and does not adhere much to the volatile part. Such, for example, is the evaporation of regulus of antimony in the *purification of gold by antimony*. See *that operation*.

The vessels employed in evaporation are basons, tests, crucibles; and these vessels are made of glass, metal, or of earth, according to the nature of the bodies on which the operation is to be performed.

CCLXXXI. EUPHORBIUM (a).

CCLXXXII. EXCREMENTS (LIQUID) *of* ANIMALS. *See* URINE.

CCLXXXIII. EXCREMENTS (SOLID) *of* ANIMALS. Alchemists who have sought every where for their great work, as they called it, have particularly operated much on the excrements of men and other animals; but philosophical chemistry has acquired no knowledge from all these alchemical labors, from the obscurity with which their authors have described them. The philosophic chemists have not much examined animal excrements. Of these, Homberg is the only one who has particularly analysed and examined human ordure; and this was done to satisfy an alchemical project of one of his friends, who pretended that from this matter a white oil could be obtained, without smell, and capable of fixing mercury into silver. The oil was found by Homberg, but mercury was not fixed by it.

The labors of this able chemist were not however useless, like those of the alchemists, because he has clearly related the experiments he made on this matter, in the Memoirs of the Academy of Sciences. These experiments are curious, and teach several essential things concerning the nature of excrements. The result of these experiments is as follows.

Fresh human fæces, being distilled to dryness in a water bath, furnish a clear, watery, insipid liquor, of a disagreeable smell, but which contains no volatile alkali; which is a proof that this matter, although nearly in a putrefactive state, is not however putrefied; for all substances really putrid furnish with this degree of heat a manifest volatile alkali. *See* PUTREFACTION.

(a) EUPHORBIUM is a very acrid, gummy, resinous juice. From an ounce of euphorbium five drams were extracted by spirit, and from another ounce five drams also were extracted by water. Both these extracts, but chiefly the spirituous, were acrid and corrosive. *Neuman.*

The dry residuum of the foregoing experiment, being distilled in a retort with a graduated fire furnishes volatile alkaline spirit and salt, a fetid oil, and leaves a residuous coal. These are the same substances which are obtained from all animal matters. *See* SUBSTANCES (ANIMAL).

Human fœces, diluted and lixiviated in water, furnish by filtration and evaporation of the water an oily salt of nitrous nature, which deflagrates like nitre upon ardent coals, and which inflames in close vessels, when heated to a certain degree.

This same matter yielded to Homberg, who treated it by a compleat fermentation or putrefaction, excited by a digestion during forty days in a gentle water-bath heat, and who afterwards distilled it, an oil without color, and without bad smell, and such as he endeavored to find; but which did not, as we said before, fix mercury into silver.

CCLXXXIV. EXPRESSION. Expression is a mechanical operation, by which the juices of many plants are obtained, and sweet oils, which are not volatile, may be extracted from many substances in which they reside superabundantly and uncombined. Such are all emulsive seeds, and some fruits, as oranges, citrons, lemons, olives, &c. An oil may also be obtained from yolks of eggs by expression.

This operation is performed by putting the substance to be expressed, previously bruised, in a machine called a press.

The plants from which the juices are to be extracted, having been bruised in a mortar, ought to be wrapped up in a strong and closely woven linen cloth, and then put into the press. The plants which are not very succulent, or too mucilaginous to give their juices by expression, ought to be mixed with some water when they are bruised in a mortar.

Grains or seeds must also be bruised before they are expressed to obtain their oil, so as to form them into a greasy paste, the oil of which exudes spontaneously. They are then to be wrapped in a strong linen cloth, and expressed. To obtain as much oil as is possible, this paste ought to be expressed betwixt two hot iron plates. But this method renders oils rancid, and therefore ought not to be used in the preparation of oils for medicinal purposes.

To obtain oil from yolks of eggs by expression, they ought previously to be hardened by baking, or even a slight torrefaction. *See* JUICES (EXPRESSED), *and* OILS (SWEET).

CCLXXXV. EXTRACT. This word, taken in the most general sense of which it is capable, is applicable to substances separated from any compound body by a proper menstruum. But it is generally confined to denote substances separated from vegetables by water.

To make an extract from any vegetable substance, it must be infused or boiled in a sufficient quantity of water, to extract from it all the substances soluble in this menstruum. If the vegetable matter of which the extract is to be made is itself succulent and watery, it need not then be infused or boiled. The juice which contains all the matter of the extract may be expressed; for in this case, the water in the plant has the same effect as the water employed in infusion or decoction.

Then

Then the infusion, decoction, or expressed juice of the plant must be evaporated till they acquire more or less firm consistence. For some extracts are made as soft as paste, and are called *soft extracts*; others are evaporated till they become dry, and are called *dry* or *solid extracts*.

The liquor from which the extract is to be made by evaporation is always more or less charged with feculent matters, earthy or resinous, which render it turbid, because these matters are not soluble in water. These matters are generally separated before the liquor is evaporated to the consistence of an extract, which may be done by clarification with the white of an egg, or otherwise. By this separation of feculent matter, soft extracts are rendered less liable to ferment and to become mouldy. But as the intention of making an extract is to preserve all that can be preserved of the principles of plants, the liquor of the extract ought not to be clarified, but it ought to be evaporated till it becomes dry, and thereby rendered not subject to change.

As extracts ought to resemble, as nearly as is possible, the vegetables from which they are obtained, they ought to be evaporated with a gentle heat, and in a water-bath; because the delicate and compounded principles of vegetables are liable to be changed by a strong heat. But to avoid the inconveniencies attending a tedious evaporation, by which a fermentation of the matter might be induced, this evaporation may be accelerated by encreasing the surface of the liquor, which therefore ought to be distributed in many flat and wide-mouthed vessels. See EVAPORATION. In this manner the Count de la Garaye prepared what he called *essential salts*, which are nothing but solid extracts, the best and most perfect which can be obtained.

From what has been said concerning extracts, we may conclude, that they are collections of the proximate principles of vegetables, and chiefly of those which are soluble in water, and which are not so volatile as to be capable of dissipation by the heat of boiling water. They contain, therefore, when well made, all the gummy, mucilaginous, saponaceous, (that is, the oil rendered soluble in water by some saline substance) bitter, or saccharine matters; and lastly, all the essential salts, acid or others, or any other saline matters, which are contained in vegetables. In well-made extracts are also found portions of the oily, resinous, and earthy principles of vegetables, which, although insoluble in water, have been extracted along with the other principles into the juice, infusion, or decoction; excepting, for particular reasons, these principles are required to be excluded. If extracts are required which shall possess as much as they can of the properties and virtues of plants, we ought not only to extract by water, but also by spirit of wine, and to mix together the substances thus extracted by these two menstruums. See ANALYSIS *by* MENSTRUUMS.

The taste of almost all extracts is bitter or saline, and somewhat like that which sugar or other vegetable substances acquire by slight burning. But this latter quality is faulty. It proceeds from a too strong heat having been employed to evaporate the extracts, by which some of the substances contained in the extract are considerably changed or even destroyed.

Several

Several dry extracts, or essential salts of the Count de la Garaye, attract moisture from the air, and even become liquid. This property is occasioned by a separation of the saline from the resinous and earthy parts of the vegetable, and which are therefore uncombined, and consequently apt to attract moisture.

These extracts ought to be preserved in well closed bottles.

CCLXXXVI. EXTRACT (MARTIAL). This name is given to a pharmaceutical preparation, which is not, properly speaking, an extract, since it is only a combination of iron with tartar, called *Tincture of Mars*, reduced to the consistence of an extract. *See* TINCTURE *of* MARS.

F.

CCLXXXVII. FALSE GALENA. This is a mineral which resembles at first view the lead ore called galena; but from which no metal is extracted. (u)

CCLXXXVIII. FALSE PRECIPITATE. This name is given to a matter which has the appearance of a precipitate, but which has not been separated from a menstruum. Such is mercury reduced into a red powder without addition, and merely by heat, improperly called *precipitate per se*, or mercury precipitated by itself: such also is *red precipitate*, which is mercury dissolved in spirit of nitre, and afterwards deprived of most of the acid by fire, without any intermediate substance. Silver, lead, mercury, separated from nitrous acid by marine or vitriolic acids or salts, are also generally considered as precipitates, and are really so, as they are actually separated from one substance by the intervention of another: but as this separation is made by the union of the precipitated metal with the precipitating acid, such precipitate ought to be distinguished from those which are nothing but the precipitated matter uncombined and single. See PRECIPITATES and PRECIPITATION.

CCLXXXIX. FAT. Fat is an oily concrete substance, deposited in different parts of animal bodies.

To obtain fat very pure, it must be cut into pieces, and cleaned from the interposed membranes and vessels; it must then be cleansed from its gelatinous matter by washing with water, till the water comes from it colorless and insipid; it is afterwards to be melted with a moderate heat, in a proper vessel, with a

(u) FALSE GALENA, *Pseudo Galena*, called also *Black-jack*, or *Blend*, is an ore of zinc, containing, besides that semimetal, generally some iron, together with the mineralizing substances, sulphur and arsenic. It is frequently intermixed with the lead ore called galena, and sometimes with the cupreous pyrites. In England the former kind is found in the lead mines of Derbyshire, and the latter in the copper mines of Cornwall. This mineral, formerly neglected as useless, has lately been employed, after a careful calcination, instead of calamine, for the manufacture of brass, and might also be employed as calamine is, for the extraction of zinc. For these purposes, that kind of blend is fittest which contains most zinc, and least of iron and arsenic. Such is the blend of Derbyshire, which is a very rich ore of zinc. This kind is more laminated in its texture, and of a greyish color when scratched; whereas the blend found in Cornwall has a more tessellated texture, consisting of oblong parallelipipedons, is of a reddish color when scratched, and contains a larger quantity of iron and arsenic.

little water; and it is to be kept thus melted till the water be entirely evaporated, which is known by the discontinuance of the boiling, which is caused by the water only, and which lasts till not a drop of it remains: it is afterwards to be put into an earthen pot, where it fixes; then it is exceedingly white, sufficiently pure for the purposes of pharmacy or chemical examination.

Fat thus purified has very little taste, and a weak, but peculiar smell.

Mineral acids exhibit the same phenomena with fat, as they do with the fixed sweet oils of vegetables, which contain nothing gummy or resinous, and which do not dry. Such is the oil of ben, oil of olives, and all those which chemists call *fat oils.*

Alkalis dissolve fat, as they do these oils, and form a similar soap. Fat contains no principle so volatile as to be raised with the heat of boiling water. It does not inflame but when heated in open air so as to rise in vapors. Lastly, by age it contracts an acrid and rancid quality.

When fat is distilled with a heat superior to that of boiling water, which must therefore be done in a retort, and in a naked fire, first an acid phlegm arises, and a small portion of oil which remains fluid. As the distillation continues, the acid becomes stronger, and the oil thicker, and at last it congeals in the receiver. No other principle arises during this distillation: and lastly, when the retort is red, nothing remains but a very small quantity of that kind of coal which cannot be burnt without very great difficulty. *See* COAL.

If the congealed oil which is found in the receiver be again distilled, more acid is obtained, and an oil which does not congeal; and thus by repeating the distillations the oil is more and more attenuated. While it is thus deprived of its acid, it acquires a more and more penetrating smell; and thus by distillation alone it may be rendered as volatile as essential oils, and capable of rising with the heat of boiling water.

From all these properties of fat we may perceive it is a sweet concrete oil, not volatile, and perfectly analogous to butter and wax; and that its consistence, as well as the consistence of these analogous substances, is caused by an acid intimately united with it, which cannot be separated but gradually and by repeated distillations. Fat, and all other analogous oily matters, cannot be heated sufficiently to be raised into vapors, without suffering a considerable alteration, and even decomposition. The vapors which rise from it, when heated in open air, are the same as those which rise when distilled in close vessels. They consist of acid and attenuated oil. This acid is remarkably penetrating, acrid, and volatile; it irritates and inflames the eyes, the throat, and lungs; it makes the eyes shed tears, and excites a cough as much as volatile sulphureous acid does, although its nature be very different.

When fat is in its natural state, and has not yet suffered any alteration, its acid is so well combined with its oily part, that none of its properties can be perceived. Thus fat, in good condition, is very mild, and used successfully in medicine, particularly externally, for its lenient quality; but, notwithstanding its great mildness, before it has been heated sufficiently to decompose it, and while it is yet fresh, it becomes exceedingly acrid, irritating, and caustic, when its acid is partly disengaged by fire or by time.

When fat is become very rancid, not only its medicinal effects, but also many of its essential properties, are totally changed, particularly its property of resisting

resisting the action of spirit of wine: for this menstruum, which does not affect pure and unchanged fat, dissolves some portion of fat which has been strongly heated, or which has become rancid. This effect can certainly proceed from no other cause, than that the acid of the fat disengages itself in both these cases. Mr. Macquer has shewn this in his Memoir concerning the Cause of the different Solubility of Oils in Spirit of Wine. We shall speak more fully on this matter at the article OIL. Mr De Machy, an intelligent apothecary of Paris, and an able chemist and observer, has made a remark upon this subject which corresponds with this opinion; which is, that all the rancidity of fat may be taken from it by treating it with spirit of wine. Now, this evidently happens, because the spirit of wine dissolves all the portion of fat which is disengaged from its acid; that is, all the rancid part, while it does not touch that which is not changed. This practice may be advantageously employed for the preservation or recovery of some fats used in medicine, but which are rare, and not to be procured in their recent state.

The decomposition of fat, from which may be obtained acid, oil, a very small quantity of residuous coal, and not a particle of volatile alkali, proves evidently, that this substance, although elaborated in animal bodies, of which it makes a part, has not the marks of an animalised matter; it therefore seems to make a separate class, and to be produced from the oily parts of the aliments which could not enter into the composition of the nutritive juices: it is consequently an oil superabundant to nutrition, which nature deposites and reserves for particular purposes. One of the chief uses of fat probably is to receive into its composition, to blunt and correct a great part of the acids of the aliments, and which are more than are requisite to the composition of the nutritive juice, or which nature could not otherwise expel. This is certain, that the greater the quantity of aliments is taken by healthy animals above what is necessary for their nourishment and reproduction, the fatter they become. Hence animals which are castrated, which are not much exercised, or which are come to an age when the loss and production of the seminal fluid is less; and which, at the same time, consume much succulent aliment, generally become fatter, and sometimes exceedingly so.

Although fat be very different from truly animalised substances, and appears not easily convertible into nutritive juices, it being generally difficult of digestion, and apt to become rancid, as butter does in the stomachs of many persons; yet in certain cases it serves to the nourishment and reparation of the body. Animals certainly become lean, and live upon their fat, when they have too little food, and when they have diseases which prevent digestion and production of the nutritive juice; and in these cases the fatter animals hold out longer than the leaner. The fat appears to be then absorbed by the vessels designed for this use, and to be transformed into nutritive juice.

The fats of different animals differ little. They have all the same essential properties, and only vary sensibly in consistence. Frugivorous animals, and particularly sheep, have very firm fat; most reptiles, and particularly fish, which are almost all carnivorous, have a soft and sometimes a liquid fat. *See* BUTTER, WAX, *and* OIL.

CCXC. FEATHERS. *(x)*

CCXCI. FENNEL. *(y)*

CCXCII. FENUGREEK. *(z)*

CCXCIII. FERMENT. A ferment is a ſubſtance actually fermenting, or ſtrongly diſpoſed to ferment, and which is employed to determine and excite another body to fermentation; ſuch are yeaſt, leaven, and other ſuch ſubſtances. *See* FERMENTATION.

CCXCIV. FERMENTATION. Fermentation is an inteſtine motion, excited ſpontaneouſly, with the aſſiſtance of proper heat and fluidity, betwixt the integrant and conſtituent parts of certain very compound bodies, from which reſult new combinations of the principles of theſe bodies.

All vegetable and animal matters, into the compoſition of which enter a certain quantity of fluid oil and earth, rendered perfectly ſoluble in water by the intervention of a ſaline matter, being diffuſed in a ſufficient quantity of water to become liquid, or at leaſt ſoft, and being expoſed to heat from a few degrees above the freezing point to twenty-five and more, and when the communication with air is not entirely ſtopt, ſuffer ſpontaneouſly the fermentative motion, which entirely changes the nature and proportion of their principles.

But this fermentation, and the new compounds produced by it, differ conſiderably both in properties and proportions, according to the nature of the fermented ſubſtance, and the circumſtances of the fermentation.

We may diſtinguiſh three particular kinds of fermentation, or three degrees of the ſame fermentation, which refer to the three principal products which reſult from it.

The firſt is called *vinous* or *ſpirituous fermentation*; becauſe it changes into wine the liquors which undergo it, and becauſe from this wine may be obtained an inflammable ſpirit, miſcible with water, called *ſpirit of wine*.

The ſecond kind of fermentation is called *acid* or *acetous*, becauſe the product of it is an acid, or *vinegar*.

The third fermentation is called the *putrid* or *putrefaction*. It might alſo be called the *alkaline* fermentation, becauſe much alkali is diſengaged by it.

All matters ſuſceptible of the ſpirituous fermentation may afterwards undergo the acid, and, laſtly, the putrid fermentation; but ſome ſubſtances are not ſuſceptible of the ſpirituous fermentation, but proceed firſt to the acid, and afterwards to the alkaline or putrid fermentation; and laſtly, ſome ſubſtances are ſuſceptible of the putrid fermentation only. Further, a ſubſtance which

(x) FEATHERS. From ſixteen ounces of feathers Neuman obtained ſix ounces, two drams of ſpirit, two ounces and two drams of ſalt, one ounce two drams of oil, and a reſiduum, from which, after calcination, twenty-ſix grains of ſaline matter were elixated.

(y) FENNEL. The leaves and ſeeds of common fennel contain an eſſential oil. The oil obtained from the leaves on the upper part of the plant is much finer, lighter, and more ſubtle than the oil obtained from the lower leaves. The former oil ſwims on water, and the latter oil ſinks. *Neuman.*

(z) FENUGREEK. The ſeeds of this plant contain an expreſſible oil blended with reſin and mucilage, but no eſſential oil. From ſixteen ounces, eleven drams were extracted by water; and from the ſame quantity, four drams and a half were extracted by ſpirit of wine. *Neuman.*

having undergone the ſpirituous fermentation, has proceeded to the acid fermentation, cannot be again made to undergo the ſpirituous, but paſſes neceſſarily to the putrid. Alſo thoſe ſubſtances which have undergone the acid fermentation directly, that is, without previouſly paſſing through the ſpirituous, are only then ſuſceptible of the putrid, and not of the ſpirituous fermentation; and the ſubſtances which paſs directly to the putrefactive fermentation cannot be made to undergo, at leaſt ſenſibly, the acid, and ſtill leſs the ſpirituous fermentation. Laſtly, any matter ſuſceptible of the ſpirituous fermentation cannot be made to putrify without previouſly paſſing through the ſpirituous and acid fermentations.

Theſe conſiderations have induced moſt chemiſts, and particularly the great Stahl, to conſider theſe fermentations leſs as three operations diſtinct and independant of each other, than as three principal and diſtinguiſhed degrees of one and the ſame fermentative motion, by which nature endeavors to reſolve, and to reduce into a ſimilar condition, all the moſt compounded bodies, into the combination of which enters the oily principle; that is, all animal and vegetable ſubſtances.

We may add, that while vegetable and animal ſubſtances ſuſceptible of fermentation make part of the living vegetable or animal, they undergo fermentation only in a ſlow and inſenſible manner; becauſe they are preſerved from it by the vital motion, and becauſe this ſlowneſs is neceſſary for the vegetable and animal economy: but when the life of organiſed bodies ceaſes, then, as nothing in their juices or proximate principles prevents their diſpoſition to change their nature and to be decompoſed, all theſe ſubſtances ſenſibly acquire the fermentative motion, and paſs with more or leſs rapidity and regularity through the periods of change which they have ſtill to undergo, according to the concurrence of circumſtances which generally favor fermentation.

According to this idea, fermentation, taking it altogether, would be nothing elſe than putrefaction; to which all animals and vegetables naturally and continually tend, during their life, ſlowly and inſenſibly; but after their death, quickly and ſenſibly.

At the beginning of this article we obſerved what the neceſſary conditions were for fermentation of any body, and hence the means by which it may be prevented or ſuſpended are eaſily deduced. Theſe means are, intenſe cold, want of air and of water, and, laſtly, a diſproportion of the principles of the bdoy expoſed to fermentation.

The moſt fermentable liquors, as the juices of grapes and other ripe fruits, do not ferment when expoſed to too great cold. The blood and fleſh of animals are preſerved from corruption by froſt. They may be alſo preſerved under the exhauſted receiver of an air-pump, or by drying perfectly. They may particularly be preſerved by this latter method any time, without ſuffering the leaſt alteration.

We are to remark upon this ſubject of preventing fermentations in fermentable ſubſtances, that when only the neceſſary degree of heat is employed to deprive them of their ſuperabundant moiſture, and their compoſition conſequently is not changed; we may, by mixing them again with the proper quantity of water, reſtore to them the ſame tendency to ferment which they had before they were dried. This obſervation is particularly applicable to matters ſuſceptible of the firſt and laſt degrees of fermentation, and we ought to conclude

from thence, that although the products of the spirituous and alkaline fermentation are more volatile than water, yet the fermentable substances contain no principle which is not less volatile than water.

The last method of preventing or retarding fermentation in fermentable substances is, as we said, to change the proportion of their proximate principles, which is conveniently done by mixing them with some substance which can unite itself to these principles, and which is not itself fermentable. Such are spirit of wine, acids, and even all saline substances. For this reason wine is preserved in the same state by penetrating it with sulphureous acid; and also animal matters are preserved from corruption by mixing them with spirit of wine, common salt, or any other salts.

Those vegetable and animal substances only are properly fermentable which contain oil. The action of minerals, or of their principles on each other, nor even the action of decompounded vegetable and animal substances, can be considered as true fermentations, except we so far extend the meaning of the word fermentation as to include the spontaneous and intestine motion of decompounding pyrites, by which new salts are formed; the changes produced upon the imperfect metals by air and by water; the rancidity of oils; and other changes, which appear to differ essentially from the fermentation of animal and vegetable matters.

The effervescences which happen betwixt bodies not much compounded, when they mutually dissolve each other, such as the effervescences perceived when acids unite with earths, alkalis, or metals, are much more different from true fermentation, and have never been confounded together but by persons entirely ignorant of chemistry.

We may judge from what we have said concerning fermentation in general, how important this matter is for the attainment of a knowledge of animal and vegetable substances; but we cannot form an adequate notion of it, without considering attentively the particular phenomena which appear in the several kinds or degrees of fermentation. Wherefore, upon this the articles KINGDOM (VEGETABLE), KINGDOM (ANIMAL), WINE, SPIRIT of WINE, TARTAR, VINEGAR, *and* PUTREFACTION, may be consulted.

CCXCV. FILTRATION and FILTERS. Filtration is an operation by which the heterogeneous parts mixed with a liquor are separated, or by which certain matters are freed from an useless liquid. Filtration is generally performed by means of filters. A heap of small parts of any substance, as sand, may also be employed for filtration in some cases.

The rules of filtration are very simple. The chief of these are, that the filter shall contain nothing which the liquor that passes through is capable of dissolving; that it shall not be liable to be attacked or corroded by the liquor; and that its pores shall be smaller than the particles of the matter to be separated from the liquor.

A liquor cannot be filtrated unless its fluidity and thinness be proportioned to the pores of the filter. Liquors which are viscid and thick, as syrups and mucilages, and those which are very thick, as very strong solutions of some salts, do not pass, or with great difficulty, through filters whose pores appear otherwise sufficiently large in proportion to the fineness of their parts. This proceeds from the adhesion which these parts have to each other.

The

The filtration of these liquors is generally much forwarded by heat. Strong solutions, for instance, of salts, large proportions of which are soluble in water, as nitre, Glauber's salt, and others, require to be filtrated when boiling hot.

When the parts of a matter diffused in this liquor adhere to this liquor, they cannot be separated by filtration. This adhesion must be previously destroyed. For instance, the expressed juices of plants are impregnated with a resinous, earthy, fine matter, adhering to these juices, and destroying their transparency. The whey of milk also is turbid from the many fine caseous parts adhering to it. These liquors cannot be clarified by filtration without a previous preparation; for they cannot pass through the pores of a filter close enough to retain the heterogeneous particles which disturb their transparency; and through a filter open enough to give them passage, they would pass in their turbid state.

Such liquors are rendered capable of filtration by coagulating and collecting [illegible] heterogeneous parts. This is effected by boiling, and still better by whites of eggs mixed and boiled together with these turbid liquors. Whites of eggs, when they coagulate, collect and agglutinate the heterogeneous parts, which then appear in larger molecules, and float freely in the liquor without adhering to it. This liquor is then in a state of filtration, it passes clear, and the matter which rendered it turbid remains upon the filter. The fine caseous parts which disturbed the transparency of whey are so well mixed in it, that, besides whites of eggs, some cream of tartar must be added, to procure the required [illegible]ination.

[illegible] used as filters are woollen stuffs, linen cloths more or less [illegible] and [illegible] paper. The form of filters varies according to the quality and quantity of the [illegible]ers to be filtrated. Some of them are hollow inverted cones, [illegible]re used in pharmacy and cookery than in chemi[illegible]re filtered. The filter most frequently used in chemistry is paper, in the making of which no paste or size has been employed.

[illegible] only of matter is to be filtrated, the paper must be [illegible]orm of a funnel, and to be placed in a glass funnel, [illegible] filter and the sides of the funnel, to prevent [illegible]mediately and in all its extent to the funnel, [illegible]

[illegible], a cloth is to be fixed to the four corners [illegible] be stretched tight: to the cloth is fitted paper, upon wh[illegible] poured.

The first port[illegible] li[illegible] filtration are almost always more or less t[illegible]ured again upon the filter, and even more [illegible]ctly clear. This happens because the pores of the filter, [illegible]s or [illegible] afterwards contracted by the swelling occasioned by the liquor, [illegible] stopped up by the sediment which is deposited upon t[illegible]

CCXCVI. FIRE. Chemists consider fire, as also the other elements, in two very different views: first, as it enters into the composition of many bodies, of which it is a principle or constituent part; and secondly, as being pure, free, not entering into any compound, but acting sensibly and strongly upon all natural bodies, and producing effects as a powerful agent in all chemical operations.

operations. In this latter point of view we ſhall conſider fire in this article. It will be conſidered as a principle under the article PHLOGISTON.

Pure, free, uncombined fire ſeems to be a collection of particles, the matter of which is ſimple, homogeneous, and entirely unalterable. All the properties of this element ſhew that its particles are infinitely ſmall, have no ſenſible adheſion to each other, and that they have a very rapid, continual motion in all directions, which is eſſential to them.

From this definition, fire appears to be a body eſſentially fluid, and many facts concur to prove that it is the only body eſſentially fluid, conſequently the cauſe of the fluidity of other bodies; and that as it alone counterballances the general tendency of all the other parts of matter towards each other, they are prevented by it from uniting into one immenſe, homogeneous, and perfectly hard maſs.

Whence can ſo aſtoniſhing a difference proceed between the properties of the primitive integrant molecules of fire, and thoſe of the integrant parts of all other matter? Is fire then not material, or not compoſed of matter, as its properties have induced ſome philoſophers to think? Is it matter of a peculiar kind? Or does, as a great geometrician thinks, the attraction of the parts of matter become negative, and changed into repulſion, when theſe parts become infinitely ſmall, and can come infinitely near to each other; which ſeems very probably to be the caſe with the particles of fire?

We have not facts enough to decide concerning theſe different opinions. We ſhall, therefore, confine ourſelves to inveſtigate the eſſential properties of fire, chiefly thoſe which influence moſt in chemical operations and chemical phenomena.

Fire can with great facility penetrate, or ſeparate itſelf from, any body however denſe; that is, any body whatever may be heated by expoſure to fire; or cooled to its former temperature, by removing it from that expoſure.

From this effect we may infer the infinite ſmallneſs of the integrant parts of fire; and we may perceive the cauſe of its equal diſtribution through all bodies, when it is not determined by ſome particular cauſe to penetrate one body in greater quantity than another.

In fact, all ſubſtances whatever, which are placed in any given degree of heat, and obliged to remain there, acquire preciſely the ſame degree of heat. This fact has been aſcertained by inſtruments fit for meaſuring the degrees of heat.

The effects which the fire produces, or rather heated bodies, upon our ſenſes, are ſenſations of heat and light; but theſe ſenſations are not excited but when the fire is in a certain quantity; for every known body contains a certain portion of uncombined fire, and yet not any body which is not lighted or ſtrongly heated, excites in us any ſenſation of heat or light. Beſides, in certain circumſtances, a body may appear luminous, although it has no more ſenſible heat than the ſurrounding bodies. This is proved by the effects of ſeveral phoſphoric bodies, ſuch as the ſcales of fiſh, rotten wood, glow-worms; all which ſhine in the dark, although no more heated than the ſurrounding bodies. Alſo certain ſubſtances may be ſo penetrated with free and active fire, as to excite ſenſations of heat, and even to burn, although they do not appear luminous even in the dark. Amongſt theſe ſubſtances are ſtones, metals, and even

water,

water, all which may be ſo heated as to excite pain to perſons touching them, although they are not luminous.

Hence we ought to conclude, that the ſenſations of heat and light are in many caſes inſufficient to prove the preſence of any given quantity of fire in bodies.

We ought alſo to remark, that although all bodies penetrated with much fire are neceſſarily hot and luminous; heat, and not light, is the only certain ſign of the preſence of fire. The reaſon of this is, that bodies may be very luminous, without any change being induced into any of their eſſential qualities in theſe two contrary ſtates; whereas the difference of more or leſs heat produces in all bodies alterations of their properties very ſenſible and proportionable to the difference of heat.

Theſe conſiderations ſeem to have induced ſome philoſophers to imagine, that light is a being which is indeed rendered ſenſible by fire, but diſtinct and different from it. According to this opinion, heat is only a property of fire; whereas light is a diſtinct and independant ſubſtance. This opinion appears to be even demonſtrated, when we conſider that light may be decompoſed by refraction, as Newton's experiments ſhew; and that it is not, as pure fire is, capable of pervading all bodies, is proved by the opacity of many bodies, and by the reflexion of light.

However that may be, as heat occaſions more or leſs ſenſible changes in the qualities of all bodies; and that its whole action by which it influences any body conſiſts in the fluid quality, or, to ſpeak more accurately, the eſſential fluidity of fire, of which heat is only an effect; we ought here only to conſider the general effects produced by fire upon all bodies by heating them more or leſs.

Theſe effects, although diverſified, depend nevertheleſs on one principle and primary change produced upon all bodies, by which they are rarefied or made to occupy a larger ſpace. In fact, every ſolid and fluid body, when penetrated by a greater or leſs quantity of diſengaged fire, is more or leſs encreaſed or diminiſhed in ſize than it was before.

This principle has ſuggeſted to philoſophers ſeveral different inſtruments by which this dilatation of heated bodies, or rather the heat which is the cauſe of it, may be meaſured; and quantities of fire, too ſmall to be eſtimated by our ſenſes, may be appreciated. The chief of theſe inſtruments is the THERMOMETER; *which ſee.*

As bodies are dilated by fire, their ſpecific gravity muſt conſequently be diminiſhed, and the adheſion of their integrant parts muſt alſo be diminiſhed. *See* AGGREGATION, INTEGRANT PARTS, *and* GRAVITY.

Theſe two great effects, produced by fire upon all bodies, are the moſt important and moſt neceſſary to be conſidered, relatively to chemiſtry. We may indeed ſay, that they are the only effects; for excepting combuſtion, which is a peculiar property of inflammable bodies, every chemical operation is performed either by a diminution of ſpecific gravity, or by a greater or leſs disjunction of the integrant parts of bodies, as we ſhall ſee.

Some ſubſtances are capable of a greater dilatation or diminution of their ſpecific gravity, than others, by fire. Thus certain matters are ſo much rarefied by even a moderate heat, that they ſeem to loſe all their ſpecific gravity, or

become

become at least specifically lighter than all the surrounding bodies: hence these substances, when heated to a certain degree, are raised as bodies would be without gravity. All substances which have this property are called in general *volatile substances.* *See* VOLATILITY. Other bodies are so little dilatable by fire, relatively to their density, that the greatest heat that can be given to them produces an almost insensible diminution of specific gravity. These are called, from their being almost unalterable in this respect by fire, *fixed bodies.* *See* FIXITY.

Hence, if we expose to fire a compound body containing some fixed and some volatile principles, the former becoming specifically lighter ought to rise in vapors, and to separate themselves from the latter, which are unalterable in this respect. But as almost all compounds contain principles differing so much in volatility and fixity, that some of them may be raised and sublimed, while others shall remain fixed with some given degree of heat; we may therefore, by heat alone, make many analyses and decompositions. If, for example, we expose a compound of regulus of antimony, which is a volatile semi-metal, and of gold, which is a fixed metal, to a heat so strong that the volatility of the regulus of antimony shall take place; then this semi-metal, being raised by its acquired levity, will be sublimed in vapors, and will be separated from the gold, which will remain fixed and pure. *See* DISTILLATION, SUBLIMATION, EVAPORATION.

The observation we have just made concerning the changes in the specific gravity of bodies, which the dilatation occasioned by heat produces, ought also to be applied to the diminution of the adhesion of their integrant parts, which is an effect of the same cause; for if a body be dilated by heat, the contiguity, and consequently the adhesion, of its integrant parts must be diminished: but in this respect the several natural substances differ very much; for the integrant parts of some bodies, when dilated by heat, are so separated and disjoined, that they seem no longer to cohere. If these bodies be naturally solid, they become fluid when they are penetrated with a sufficient quantity of disengaged fire, and are called *fusible bodies.* Those bodies, the integrant parts of which cannot be entirely disjoined by fire, are called infusible or refractory: but as the aggregation of a body is broken when it is fused, and as this destruction of aggregation is a necessary condition for the combination of bodies with each other; fire therefore, by rendering solid bodies liquid, has influence as a principal agent in all combinations. *See* COMBINATIONS, SOLUTIONS, FUSIBILITY, and REFRACTORY.

As all chemical operations may be reduced to decompositions and combinations, fire is therefore in chemistry, as in nature, an universal agent. Thus we know that, although decompositions and analyses may be made by menstruums without any more than the natural heat, yet as those menstruums can only act when rendered sufficiently fluid by heat, fire therefore acts in these analyses as necessarily as in those which are occasioned by the immediate application of heat.

We ought to observe concerning this subject of the volatility, fixity, fusibility and infusibility of bodies, first, that all these qualities are properly only relative. Not any body is entirely fixed and unfusible, and those which we consider as such would be reduced into vapors, as volatile bodies are, if they were exposed

exposed to a heat infinitely stronger than any we can excite. Thus a body will appear fixed, or infusible, when compared with other very volatile and very fusible substances; while it shall be considered as volatile or fusible, when compared with others more fixed and less fusible.

In the second place, as volatility and fusibility are effects of one and the same cause, namely, of the dilatation occasioned by the presence of a certain quantity of uncombined fire in bodies, these two qualities are properly the same, in more or less eminent degrees; and in this sense, volatility ought only to be considered as the highest degree of fusibility. Accordingly, substances which are habitually liquid, and which ought therefore to be considered as the most fusible, are all very volatile, and may be raised into vapors with very little heat; while, on the contrary, matters that are hard, and not very dilatable; those, in short, the aggregation of whose parts is the firmest and most difficultly to be broken, and which are therefore the least fusible, are also the most fixed.

The aggregation of all bodies, when reduced into vapors or fused, is broken, but more so when reduced into vapors, than when merely fused. Accordingly, the most effectual of all methods for combining substances which cannot be easily united, or which cannot be joined while the aggregation of one of them is sensibly preserved, is, if possible, to reduce them into vapors, and to make these vapors meet.

All the effects which fire produces, as an agent in chemical operations, are reducible, as we see, to those we have mentioned. The quantity of uncombined fire which flows perpetually from the sun, and diffuses itself through all its sphere, is sufficient to produce all the separations and combinations which we daily see effected by nature: but as the heat caused by the sun is very limited, chemistry would be confined almost to the contemplation of natural operations, if we had not methods by which pure and uncombined fire may be made to enter bodies, or to quit them in greater or less quantities.

The methods of encreasing the quantity or the activity of uncombined fire in bodies may be comprehended in the following three:

First, by concave mirrors and by convex glasses, a number of the rays of the sun, proportionate to the size and good quality of the instruments, may be collected into one point, called the *focus*. Bodies exposed to such a focus are penetrated with an infinitely greater quantity of uncombined and active fire than they have naturally. They are then ignited, inflamed, dilated, fused, or volatilised, according to their particular natures. The heat of such a focus is the greatest that art has produced. It is even exceedingly too strong for most chemical operations, and ought to be applied to the most fixed and refractory bodies only. As such a focus is also very small and inconvenient for the performance of any operation, and as large mirrors and lenses are very rare and dear, this fire is not much used for chemical operations. Nevertheless, several very important chemical experiments were performed by collected solar heat; as the decomposition of gold, published by Homberg, if it be true; the fusion of platina, by Messrs. Macquer and Beaumé; and of several other bodies which could not be fused by other fires, without addition of other substances, by other chemists, at different times.

Secondly, experience has long ago taught us, and even the most ignorant nations know, that heat and all the effects of fire may be occasioned by friction and

percussion of hard bodies. The heat excited by this method may be very considerable, and even comparable to that of collected solar fire. It is in general proportionable to the force, rapidity, intensity of friction and of percussion, and to the hardness of the bodies rubbed or struck. This heat is also not much used in chemical operations: it, however, frequently occurs in many chemical experiments, as in fermentations, effervescencies, and solutions. It occurs whenever bodies unite together; and is proportionable to the rapidity and force with which they act upon each other. It is produced by the friction and collision of their integrant parts; which shows, that the primary integrant parts are exceedingly hard, even in bodies generally soft or fluid; for these substances, when dissolving, produce as much heat as those which are most hard, and whose aggregation is most firm.

The third cause which produces or excites heat is the combustion of compound bodies, in the combination of which fire enters as an element or principle, and which are therefore called inflammable or combustible bodies.

The principal phenomenon presented by these bodies is, that by mere contact with any other body, inflammable or not, but which is ignited, they are kindled, inflamed, give much heat and light; in a word, produce all the same effects as the collected solar heat, or the allisions of hard bodies. This continues till the whole substance of fire, which entered into their composition, and which was inactive, has resumed all the activity of pure and uncombined fire, and is entirely dissipated.

This inflammation of combustible bodies is undoubtedly one of the greatest and most astonishing phenomena of nature: but it is also one of the most difficult to be conceived. We cannot expect to understand it well, till we know better than we do at present the essence and true state of fire when combined, and constituting a principle of the bodies containing it, called *phlogiston*. *See* PHLOGISTON.

We must observe at present, that as the combustion of inflammable bodies produces all the effects of fire, pure, uncombined, and active; it is also the most convenient method, by which fire can be applied by chemists to several bodies.

The most common inflammable substances, such as wood, fossil coal, charcoal, are most generally employed in chemistry, in the arts, and in the ordinary purposes of life, in all operations where fire is requisite.

As chemists have occasion to employ all the several degrees of heat, from the weakest to the strongest, they have discovered methods of applying any required degree through intermediate substances, and still better by the disposition and construction of furnaces, in which the combustible matters, and those to which the fire is intended to be applied, are contained. *See upon this subject* BATHS, COMBUSTION, FURNACES. *(a)*

CCXCVII. FISH. *(b)*

(a) See the Supplement I. *article* FIRE.

(b) FISH. Neuman obtained from sixteen ounces of fish analysed by distillation, thirteen ounces two drams and a half of volatile alkaline spirit, five drams of concrete salt, three drams of oil, and an ounce four drams and a half of residuum, from which, by calcination and elixation, twenty-five grains of saline matter were extracted. The proportion of volatile salt thus obtained from fish is considerably greater than that from flesh.

CCXCVIII.

CCXCVIII. FIXITY. Fixity is a property, by which a body resists the action of fire, without being raised and dissipated in vapors. It is the opposite quality to volatility.

The degree of resistance which a body ought to give to fire, to entitle it to the character of being fixed, is not determined. Thus substances are considered to be fixed almost always relatively to others which are less fixed.

As we do not know the ultimate degrees of the activity of fire, we cannot say whether any bodies in nature be capable of resisting this extreme degree of fire without sublimation, or be absolutely fixed.

Those substances, however, are generally considered by chemists as absolutely fixed, which lose nothing of their quantity by exposure to the most intense heat which they can produce. The purest and simplest earthy principle is a substance of this kind, and is perhaps the only one which can be considered as naturally fixed, and is the principle of fixity of all the rest.

Chemists commonly call many substances fixed, which do not deserve that name, but comparatively with others, as we have already mentioned. In this sense, for instance, vitriolic acid is sometimes called a fixed acid, by which is only meant that it is less volatile than others. For the same reason, regulus of antimony, and other semi-metals, may be considered as fixed substances when compared with essential oils and ether, particularly in operations where they remain fixed, when exposed to a heat sufficient to evaporate essential oils or ether; whereas these semi-metals may be considered as volatile, when compared with metals properly so called.

The fixity of bodies seems certainly to proceed from their little dilatability by fire, and this defect of dilatability is occasioned by the attraction or adhesion of the integrant parts of these bodies. See FIRE and VOLATILITY.

CCXCIX. FLAME. Flame is a collection of vapors of combustible bodies actually burning, and which are themselves in the motion of combustion. (c)

(c) FLAME is generally said to be an ignited vapor, or red-hot smoke. Nevertheless, *Flame*, *Vapor*, and *Smoke*, are things distinct from each other, and ought not to be confounded together. We shall endeavor to describe and distinguish these; and first, of *Vapor*.

By the action of certain determinate degrees of heat, with or without access of air, all liquid and some concrete bodies are so dilated, as to occupy a much larger space than before this exposure to these determinate degrees of heat; acquire a considerable expansive power, or elasticity; and become transparent and invisible. They are then properly vapors. This state they retain while exposed to the same heat by which it was produced; but by application of cold, they are condensible into palpable substances, similar to those from which they were formed, if they happened to consist of homogeneal parts, as water and mercury do; or they are condensible into palpable substances which are the constituent parts of the bodies subjected to heat, if these bodies happened to consist of parts not homogeneal, as plants do of water and essential oil. If the vapor consists of inflammable parts, it may be kindled by contact with any ignited body; by which means, together with access of air or nitrous acid, it may be made to undergo those effects which are produced upon all bodies during their combustion, namely, the decomposition of its parts, the dissipation of its phlogiston, and emission of heat and light; but vapor thus ignited, rendered visible, and in the act of combustion, by access of air, or nitrous acid, is *flame*. This flame, or vapor decomposed by combustion, is not condensible, as we may easily conceive, into such palpable substances

As bodies cannot burn but by touching immediately the air, and as for this reason they only burn at their surface, flame, which is the only truly burning part of bodies which appear in actual combustion, is always at their surface. It is luminous and ardent throughout its whole thickness, because it is only a mass of adjacent, but disunited inflammable parts, which touching the air on every side, burn altogether and throughout their whole substance.

substances as the undecomposed vapor is; but into some only of the constituent parts of these substances, the rest being destroyed by the combustion. Thus the vapor of spirit of wine is again condensible into spirit of wine; but from the flame of spirit of wine little can be obtained by condensation but the water, which was one of the constituent parts of that spirit; the other parts, especially the phlogiston, being destroyed by the combustion.

Not only the vapor of an inflammable body, but also the inflammable body itself, without being previously changed into vapor, may, by contact with an ignited body, or any other mode of application of heat, as friction, percussion, &c. together with access of air or nitrous acid, emit a flame, which consists, as in the former case, of particles of that body in the act of combustion. Thus by applying a hot iron to sulphur, we may see a flame immediately produced upon the surface of the sulphur. We may easily conceive that bodies thus kindled can only flame at their surfaces, because there only they are contiguous to air: but when nitre is intimately mixed with the inflammable substance, as in gun-powder, the whole substance, its interior as well as its exterior parts, are instantly inflamed; because the nitrous acid has, like air, the property of maintaining combustion. Hence also we may easily conceive why the external surface of a flame, by being contiguous with air, is much hotter than its internal parts, as may easily be shewn by applying any substance, alterable by heat, alternately to the exterior and interior parts of the flame of a candle; and when the flame has a considerable diameter, as of a foot or eighteen inches, and is maintained only by the air contiguous to it, as when the vapor issuing at the upper mouth of a furnace for smelting iron ore is kindled by contact of any ignited body, the flame will then be found to have a thickness only of an inch or two, while the vapor near the center surrounded by this flame, is not inflamed, as appears from paper or other easily combustible matter being held in it without being kindled.

Smoke consists of palpable particles elevated by means of the rarefying heat, or by the force of the ascending current of air, from bodies exposed to heat. These particles vary much in their properties according to the substances from which they were produced. Vapors also rising from heated bodies, when condensed by the coldness of air or other contiguous bodies, become palpable, and therefore have the appearance, and may be considered as smoke. The smoke arising from combustible bodies consists of parts, some of which are generally combustible, but so difficultly combustible, that a greater heat is required than they possess while they are smoke, to effect their combustion. The flame also of combustible bodies may be so cooled by the application of cold air, or other cold substances, as that the combustion of the particles composing it shall be checked, and these particles shall become smoke. Thus the flame of a candle is, by the coldness of the air, diminished more and more as it rises higher, till at last it is extinguished, before all its inflammable parts are consumed, and its point terminates in smoke.

The smoke of burning inflammable substances, when collected, is called *soot*. The smoke of uninflammable substances, or of inflammable substances not exposed to air, and consequently not burning, consists of the substances not altered or decomposed, but only divided, as the flowers of sulphur raised by heat in close vessels, and the flowers of sal ammoniac; or it consists of parts of these substances decomposed merely by heat, and not by combustion; as the flowers of sulphur and of arsenic, from the mineral containing these called pyrites, exposed to heat in close vessels; and the flowers of benzoin, sublimed by heat from the resin of that name.

No combustible body really burns without flame. Those, indeed, whose inflammable principle is firmly united with a great quantity of incombustible matter, such as charcoal or ashes almost entirely burnt, and most metals, seem to be consumed without sensible flame; but this appearance does not impose upon an accurate observer. The appearance of a body which really burns is very different from that of a body which is only made red-hot by being penetrated with a fire proceeding from some other substance, which does not itself burn. Let a bar of iron be compared with a flint, when both are taken out of a fire so intense as to give to each of them a white heat, and the surface of the metal will seem covered over with a small flame, which is indeed very low, but bright and sparkling; while nothing similar will appear on the surface of the flint. Besides, the flint will lose its vivid color much sooner than the iron. If we observe lead while it is scorified in a cupel under a muffle, we shall see in a striking manner that the metal shall be much more ardent and luminous than the cupel; although these two bodies are exposed precisely to the same degree of heat; but this difference can certainly proceed only from the small flame which necessarily accompanies the combustion of the metal; while the cupel which contains no combustible principle, and which consequently cannot burn, does not exhibit any such appearance.

All bodies, therefore, which do really burn, seem to burn with flame; but the flames proceeding from the different combustible bodies differ very much from each other, according to the nature of these bodies, and to the particular state of their phlogiston. I do not know whether the flame of any combustible body be entirely pure. Such a flame would be nothing else than phlogiston separated from all other substances, reduced into vapor, and actually ignited. The flames of rectified spirit of wine and of perfect coal seem to be the purest of all, because they are accompanied with no smoke nor fuliginous matter. Nevertheless, the flame of spirit of wine is accompanied with much water. *See* Spirit *of* Wine. All other flames are evidently mixed with heterogeneous substances, which discover themselves by different qualities.

The least pure of all flames is that of oils and of all oily matters, because it proceeds from very compound bodies. This flame is always mixed not only with all the volatile principles of the oil, or oily body, but also with a considerable quantity of the fixed principles which are raised by the deflagration. Besides, although it is considerably luminous, all the phlogiston which it contains is not burnt: a portion of it remains combined in the state of coal with earth. Hence the flame of all oils is accompanied with a fuliginous smoke, which blackens bodies that it touches. As this property belongs to the flames of all oils and oily matters, and to none else, it is a mark by which we may discover whether the phlogiston of any body be in an oily state. *See* Oil, Fuliginosity, Smoke, *and* Soot.

The flame of metals is also accompanied with a sensible smoke, which is even very considerable and thick in certain metals. But this flame does not, like that of oils, blacken substances which it touches; because metals are not in an oily state. *See* Metals.

Lastly, the flame of sulphur would be very pure, if it was not for the vitriolic acid, a large quantity of which is mixed with it. Perhaps the flame of this compound would be very pure, if the sulphur was previously mixt with

fixed alkali to absorb the acid, in Stahl's manner, and if it was made to burn so weakly as not to be capable of kindling combustible bodies. *See* SULPHUR.

CCC. FLINTS. *See* EARHTS (VITRIFIABLE). (*d*)

CCCI. FLOWERS. By this name is generally understood bodies reduced into very fine parts, either spontaneously, or by some operation of art; but it is applied chiefly to volatile solid substances, reduced into very fine parts, or into a kind of meal by sublimation.

Some flowers are nothing else than the bodies themselves, which are sublimed entire, without suffering any alteration or decomposition: and other flowers are some of the constituent parts of the body subjected to sublimation, as we shall see in the following articles, when we define the principal matters distinguished by the name of flowers.

CCCII. FLOWERS *of* ANTIMONY. Antimony, which is a mineral composed of the semi-metal called regulus of antimony and sulphur, is entirely volatile, and capable of being sublimed into flowers.

To make flowers of antimony, an earthen pot or large crucible, in the upper and lateral part of which is an opening, is placed in a furnace, and three or four aludels are fitted to it. The pot is to be made red-hot, and powdered antimony is to be thrown into it through the lateral opening, and the sublimation is then to be made. These projections of antimony are to be repeated till the operator judges that the inner surface of the aludels is sufficiently covered with flowers, which are to be detached from thence with a feather.

The vessels employed for this sublimation must not be exactly closed, for two reasons; first, that access of air favors and accelerates all sublimations, and particularly this. Lemery observes justly, that the operation is accelerated greatly by directing a blast of wind upon the surface of the antimony. In the second place, if the vessels were perfectly closed, they would be burst by the expansion of the vapors, or of the contained air.

Although flowers of antimony be composed of regulus of antimony and of sulphur, as the antimony itself is, they nevertheless differ from it essentially in many respects. They have not the same metallic brilliancy. Their color is different shades of white, grey, and yellow. They are powerfully emetic. These

(*d*) FLINTS are semi-transparent or opake stones, generally of a roundish form, and covered with a white crust, of a smooth, uniform, shining texture, so hard as to strike fire with steel; calcinable by fire, so as to become white, brittle, and, according to Henckel, heavier than before calcination; not [illegible]ble by acids; and vitrifiable only by the [illegible] violent heat of the largest speculum, such as that of Vilette, and not even by the focus of a lens of Tschirnhaus, according to an experiment of Neuman. They are found generally in beds of chalk and of sand, but never forming entire strata of rock, as jasper does. By long exposure to air and to the sun, they seem to decay, to lose their lustre, their firmness of texture, and to be changed to a white calcareous earth or chalk. Hence they are almost always found covered with a white chalky crust. They are also convertible into calcareous earth by fusion, or vitrification with so much fixed alkali, that they shall resolve into a liquid mass called the liquamen of flints, and by precipitation from the fixed alkali by means of acids. *See* LIQUOR *of* FLINTS.

Flints are of the class of earths called *vitrifiable*, because these earths are generally employed, together with fixed alkali, as materials in the making of glass. *See* GLASS, *and* EARTHS (VITRIFIABLE).

difference

differences prove that antimony sustains a considerable alteration by this sublimation. This alteration consists in the diminishing the connexion betwixt the sulphur and the regulus of antimony.

The difference of colors in flowers of antimony proceeds from the variable action of the fire and of the air upon this mineral during the operation. Probably the emetic quality of flowers of different colors also differs. But this difference has not been observed, as the flowers of antimony have not been much employed, because of their uncertainty.

CCIII. RED FLOWERS *of* ANTIMONY. Lemery gives a process for making the red flowers of antimony. It consists in distilling eight ounces of antimony, mixed with fourteen ounces of sal-ammoniac, or of flowers of sal-ammoniac. Some volatile alkali is raised from the sal-ammoniac, and red flowers are sublimed.

The portion of volatile alkali which rises in this operation is disengaged by the reguline part of antimony; and as one part of this volatile alkali acts at once upon the sulphur and upon the regulus of antimony, an antimoniated volatile liver of sulphur is formed. These red flowers are a kind of kermes, and differ from the ordinary kermes in having a volatile instead of a fixed alkali. They are emetic, purgative, diaphoretic, incisive, &c. as kermes is, and may be given in the same dose as kermes is; but are seldom used. However, a kermes made with volatile alkali may have peculiar virtues, and deserves the attention of physicians; but in this case it ought to be prepared in a more certain manner by employing uncombined volatile alkali.

CCIV. FLOWERS (ARGENTINE) *of* REGULUS *of* ANTIMONY. To make these flowers, regulus of antimony is put into an unvarnished earthen pot, which is to be placed in a furnace so that its bottom may be red-hot, while its upper part shall be much colder. The pot is to be covered with a lid, without luting it, and heat is to be applied during an hour or more. When the pot is cold, its internal surface, and also the remaining part of the regulus, is found covered with white flowers, in form of beautiful, transparent, and shining needles. These flowers are to be gathered with a feather. After this, a second sublimation may be commenced, and managed as the former was; and thus the whole regulus may be changed into flowers, which requires much time.

Lemery directs that a small lid or diaphragm shall be placed within the pot, at the height of three or four fingers thickness above the regulus. But this appears to be unnecessary. Mr. Beaumé does not use this second lid. He only inclines the pot so, that all the upper part of it shall be out of the furnace. He makes the bottom of it very hot; and thus obtains a large quantity of flowers.

These flowers appear to be nothing else than the earth of regulus of antimony deprived of almost all its phlogiston. They are not emetic nor purgative. They are not very volatile, and cannot easily be reduced into regulus. They are soluble in aqua regia. All these properties, together with their remaining degree of volatility, shew that they contain some inflammable principle. They have also considerable marks of a saline substance. They have not only the appearance of a crystallized salt, but are also entirely soluble in

water,

water, as Mr. Beaumé observes; although a large quantity of water, which must also be boiling, is required for that purpose. Eight ounces of boiling water are capable of dissolving half a grain of these flowers. From this property we may suspect that regulus of antimony contains a saline matter as one of its constituent parts, which is conformable to the opinion of some chemists concerning salts and metals.

Nevertheless, if we consider that regulus of antimony cannot be deprived of all the sulphur with which it is united in its mineral state, we may suppose that part of the acid of sulphur may, by uniting with the earth of the regulus of antimony, give the saline qualities to the flowers of this metallic substance.

CCCV. FLOWERS *of* ARSENIC. The white flowers of arsenic are nothing but white arsenic itself; which being a volatile substance, unalterable by sublimation, may be raised altogether, without any change.

Flowers of arsenic are made, as all other flowers are, by subliming arsenic. *See* SUBLIMATION.

We ought to observe that they are not perfectly white, unless the arsenic from which they have been sublimed has been perfectly dephlogisticated and white. If the arsenic which is sublimed be mixed with a little sulphur, the flowers will be more or less yellow, or red, according to the quantity of sulphur which is sublimed along with them. If the arsenic be in a reguline state, or considerably phlogisticated, its flowers will be more or less greyish or brown. Hence we see veins of these different colors among the arsenic which is found in commerce, and which is obtained by sublimation in great works from arsenical minerals.

As arsenic is very fusible, when these flowers fix themselves to any substance considerably heated, they suffer a kind of fusion, are agglutinated together, and form the dense, compact, heavy, shining masses which are in the shops of druggists. The nature and properties of flowers of arsenic do not differ from those of arsenic. *See* ARSENIC.

CCCVI. FLOWERS *of* BENJAMIN, *or* BENZOIN. To make flowers of benjamin, let a quantity of benjamin be put into a varnished earthen pan, which is to be covered with another inverted pan of stone ware. The edges of these two pans ought to have been ground upon a stone, so that they fit well to each other. They are to be luted together with paper dipped in paste. The earthen pan containing the benjamin is to be put upon a gentle fire, and which is not capable of raising the oil of the benjamin. With that heat the sublimation is to be performed: when the vessels are cooled, they are to be unluted, and great care is to be taken that they be not shook. If the sublimation has been performed, the inner surface of the upper earthen pan will be found covered with fine sparkling flowers like a very pure salt, forming crystals like flattened needles. A considerable quantity also of these flowers is generally found, which are not raised, and which cover the surface of the remaining benjamin. The flowers are to be swept off with a feather.

The success of this operation depends on the degree of heat given, and the time employed. If the heat be too great, a part of the oil of benjamin will rise together with the flowers, which will thence receive a dirty yellow tinge. In this case they must be again sublimed, and with a less heat. If, on the contrary,

trary, a sufficient degree of heat is not given, or the operation has not been long enough continued, all the flowers which the benjamin is capable of furnishing will not be procured. The same benjamin will, by repeating the operation, furnish more flowers.

The process formerly used to make these flowers consists in putting the benjamin in an earthen pot, to the mouth of which is fitted a paper, or pasteboard conical head. But the method described above, which is proposed by Mr. Beaumé, seems to be preferable; because the paper or pasteboard heads absorb many flowers, which are consequently lost; and also because the earthen vessel employed by Mr. Beaumé has a greater surface than the pot used in the ancient method; and quantity of surface is always favorable to sublimation.

The flowers of benjamin are a true concrete, volatile, and oily essential salt of benjamin. They have the smell of benjamin, and are inflammable, from the essential oil which enters their composition. They are soluble in water and in spirit of wine, which sufficiently proves their saline nature. Accordingly, Mr. Geoffroy observed, that this salt may be obtained by treating benjamin with water, and by crystallization.

Benjamin is probably not the only resin from which an essential salt of this kind may be obtained; perhaps, even all resins contain such essential salt, in greater or less quantity; and this is certainly one of those which contain a great quantity of it.

Flowers of benjamin are considered in medicine as incisive, dividing, and favoring expectoration, and are therefore given in the viscous asthma. They may be given from six grains to twelve. *See* RESINS, *and* SUBLIMATION.

CCCVII. FLOWERS *of* SAL AMMONIAC. The flowers of sal ammoniac are nothing else than sal ammoniac sublimed; for this semi-volatile salt suffers no decomposition by sublimation. The process for making these flowers contains nothing singular, excepting that an equal part of decrepitated common salt is generally mixed with the sal ammoniac, in order to divide this latter salt, and to facilitate its sublimation. By this sublimation, sal ammoniac may be purified from fuliginous and other matters, with which it is generally mixed. But it may be better and more conveniently purified by solution in water, by filtration and by crystallization. For this salt has the property of raising along with it in sublimation very fixed matters, as we see from the example of the flowers of sal ammoniac tinged with copper and with iron, called *ens veneris*, and martial flowers, which are nothing else than sal ammoniac sublimed [illegible] copper. *See* AMMONIAC (SAL).

CCCVIII. FLOWERS *of* SULPHUR. Flowers of sulphur are simply sulphur sublimed in the form of flowers. Sulphur cannot be decomposed [illegible] in close vessels. Therefore flowers of sulphur [illegible] from those of pure sulphur in masses. *See* SULPHUR.

CCCIX. FLOWERS *of* ZINC. Flowers of zinc are the metallic earth of this semimetal deprived of its phlogiston, and raised in light flocks from [illegible].

To make these flowers, zinc is to be put into a large open crucible, set in a furnace [illegible]. When a white heat is raised, the zinc kindles and burns with a white, vivid, dazzling flame, accompanied with a considerable

 quantity

quantity of white ſmoke. This ſmoke is condenſed in white light flocks, which float all round the laboratory. The greateſt part of theſe flocks, however, fix themſelves to the ſides of the crucible and to the zinc. They are called *flowers of zinc*, *nihil album*, or *pompholix*.

Although theſe flowers are raiſed into ſmoke in this operation, like a very volatile ſubſtance, they are really very fixed, as metallic earths are, when well dephlogiſticated; and are ſo incapable of being again ſublimed, that they reſiſt the moſt violent fire, and are ſooner melted than ſublimed. If they are then raiſed in ſmoke during deflagration, this effect is produced by the activity with which the zinc burns; and for the ſame reaſon, earths and coals extremely fixed are found in ſoot of wood and of moſt other combuſtible matters.

The flowers of zinc are ſoluble in acids, nearly as zinc is. *See* Zinc. The cauſe of this may be, that they retain ſome phlogiſton. But they are difficultly reducible into zinc, and were even believed to be incapable of reduction, till Mr. Margraaf publiſhed a method of reviving them, by expoſing them to a ſtrong heat together with ſome inflammable ſubſtance in cloſe veſſels.

In the crucible uſed for the preparation of flowers of zinc, a conſiderable quantity of theſe flowers is found fixed to its ſides, and to the ſurface of the zinc, if any remains unburnt. Theſe latter flowers are much leſs white and light than the former. They have been produced by the part of the zinc which burnt leſs vehemently than the reſt. Their color is greyiſh, from a certain quantity of phlogiſton which they retain.

Flowers of zinc alſo are obtained from furnaces in which minerals containing zinc are ſmelted, particularly that of Rammelsberg. They adhere in great quantities to the upper part of the internal ſurface of the walls of the furnaces. But as theſe flowers ſuſtain a great heat, they are half fuſed and agglutinated together, forming maſſes, which muſt be taken off frequently in order to clear the furnaces. Flowers of zinc in this ſtate are called *cadmia fornacum*, or *pompholix*. *See* Cadmia *and* Zinc.

CCCX. FLOWERS *of* VEGETABLES. (*e*).

(*e*) Flowers. In this article, which is extracted from Dr. Lewis's notes on Neuman's Chemiſtry, the *colors* only of flowers ſhall be conſidered. Very few of the colors of flowers of vegetables are durable, or can be made durable by any means known. The only permanent color is *yellow*. The *red*, the *blue*, the *purple*, the *crimſon*, and the *violet* are very periſhable. Many flowers loſe theſe colors more, by being dried, eſpecially by being ſlowly dried in a ſhady and not warm place. The colors of all of them periſh by keeping, even in the cloſeſt veſſels. The more haſtily they are dried, and the more perfectly they are ſecured from air, the longer they retain their beauty. The coloring matter of flowers extracted and applied on other bodies is ſtill more periſhable.

Blue Flowers. [illegible] of many blue flowers is extracted by infuſion in water; [illegible] from others, water acquires only [illegible] of thoſe which have been [illegible] blue color to ſpirit [illegible] give [illegible] of theſe [illegible] blue juices [illegible] acids; [illegible] by [illegible] the [illegible] the flowers have been kept

CCCXI. FLUIDITY. Fluidity is the state of a body whose integrant parts are so disunited and incoherent, that no sensible resistance is opposed to their separation in any direction; but which are nevertheless sufficiently attracted by each other, to remain adjacent, and to form an aggregate body.

Hence fluidity is a middle state betwixt hardness, in which the integrant parts of bodies adhere together firmly, and the entire want of aggregation, in which the integrant parts of bodies are so separated and removed from each other, that their mutual attraction is no longer sensible.

kept till their colors are lost, their infusions acquire a red color from acids, and a green color from alkalis, but in a less degree than when the flowers were fresh. The red color produced by acids is scarcely more durable than the original blue: applied upon other bodies, and exposed to air, it gradually degenerates into a faint purple, and at last disappears, without leaving any stain behind. The green produced by alkalis changes to a yellow, which does not fade so soon. The green made by lime-water is more permanent and beautiful. Green lakes, prepared from blue flowers by means of lime water, have been used by painters. The flowers of cyani have been much commended for affording elegant and blue pigments. But Dr. Lewis has not been able to extract from them any blue color. They retain their color, when hastily dried, longer than other blue flowers, but do not communicate their original color to any menstruum.

RED FLOWERS readily communicate their color to water; and those of a full red color give to a rectified spirit also a deep red tincture, though somewhat paler than the watery infusion. But the lighter red flowers, and those which are purplish, impart little color to pure spirit. The colors of infusions of these flowers are supposed to be heightened by acids, and to be rendered green by alkalis; [illegible] is not un[illegible]. For [illegible] by Dr. Lewis, the red colors [illegible] by [illegible] flowers [illegible] full deep [illegible] or red [illegible] alkali [illegible] pter; and the latter [illegible] alum, [illegible] ing them deeper. Wool, or silk, impregnated with a solution of alum and of tartar, receives, on being boiled with the watery infusion or decoction, a durable yellow dye. A durable yellow lake is prepared by precipitating with alum an infusion of yellow flowers made in an alkaline ley. In some of the *orange-colored flowers* the yellow matter seems to be of the same kind as that of the pure yellow flowers; but the red matter seems to be different from that of the pure red flowers. The yellow matter is extracted from these flowers by water; and the remaining red matter is extracted by spirit of wine, or by a weak solution of fixed alkali in water. Such are the saffron-colored flowers of *Carthamus*. These flowers, after the yellow matter has been extracted by water, are said to give a red tincture to ley, from which a deep red *fecula* subsides, called *Safflower*, *Spanish red*, and *China-lake*. This pigment gives a beautiful red color to spirit of wine, but none to water. The yellow *farina* or fine dust, resting on the tips of the stamina of flowers, gives a fine bright yellow color to spirit of wine, and a duller yellow color to water. The colors of both the watery and spirituous tinctures were heightened by alkalis, rendered red by acids, and again restored to yellow by adding an alkali. This is the only known instance of the yellow color of a vegetable being rendered red by acids.

WHITE FLOWERS, or their expressed juices, impart a green color to alkaline leys, but have not been observed by Dr. Lewis to give a red color to acids. The white flowers of the common wild *convolvulus* give a [illegible] yellow or orange-color to water, which is affected by acids, by alkalis, and by alum, as the infusions of yellow flowers are. The [illegible] flowers of *Leucanthemum* give a beautiful yellow color to water acidulated with spirit of nitre.

A body may be fluid in two manners; first, by the figure of its primitive integrant parts, so that each of these parts shall not touch any other but in one point, or in one infinitely small side, and consequently have but little or no adhesion. Such a body must necessarily and naturally be fluid. Fire seems to be the only body possessed of this essential fluidity.

The second manner by which a body may be rendered fluid is, to lessen the contact of the integrant parts, to disjoin them, or even to separate them from each other by the interposition of a fluid. All bodies, which can only be fluid in this manner, are evidently not essentially fluid. On the contrary, they are naturally more or less hard and solid, and can only have a mediate or secondary fluidity. Such all bodies in nature appear to be, excepting fire. Hence, without fire no fluid would exist; all bodies would cohere together, and form a single, solid mass; and hence fire is the principle of all fluidity. But when a body is rendered fluid by fire, it may then be capable of giving fluidity to other bodies. Water, for instance, the fluidity of which is certainly caused by fire, may by interposing itself betwixt the integrant parts of gums and salts, give to them a fluidity similar in some respects to its own.

We must not confound the fluidity received directly from fire with the fluidity received from bodies rendered fluid by fire. Some substances are incapable of receiving fluidity directly from fire, but only through the intervention of some other substance previously rendered fluid by fire. Such are gums, which are rather decomposed than rendered fluid by fire, but which are readily soluble in water. Other bodies may be either rendered fluid directly by fire, or secondarily through the intervention of another body previously rendered fluid by fire. Such, for instance, are salts. They become fluid when exposed alone to the action of fire, and are also capable of liquefaction by water.

The principal difference betwixt a body rendered fluid merely by the action of fire, and another body rendered fluid by the interposition of a fluid substance, is, that the integrant parts of the latter body adhere to those of the interposed substance, and that this adhesion or affinity is the cause of the fluidity of that body.

This secondary fluidity, therefore, given by interposition of a fluid substance, is nothing else than a solution. The fluidity given immediately by fire is called by chemists *fusion*; we therefore say that a salt is dissolved in water, but not fused or melted. This latter expression is frequently used, though very improperly.

These evident and important differences between the fluidity of fire, which is essentially fluid, the fluidity of bodies fused merely by the action of fire, and the fluidity of bodies rendered fluid by the interposition of others already fused, require that these different kinds of fluidity should be [illegible] by names appropriated to each. We perceive no such precise [illegible] to denote them. Bodies habitually fused might be called [illegible], and those which have only a secondary fluidity might be called [illegible] given to the primary and essential fluidity of fire.

This want of suitable expressions shews [illegible] chemists and natural philosophers [illegible] by which they give and receive fluidity. [illegible] properties of fire, and upon the effects which it produces upon other bodies, we

we have considered those substances as having an independent fluidity, which we have generally seen in a fluid or fused state; such as air, ethereal spirits, mercury, spirit of wine, and even water and oils; although we frequently see these two last mentioned substances become solid by cold, or want of active fire. The fixation of mercury by a sufficient degree of cold, the possibility of which is suspected in the *Elements of the Theory of Chemistry*, and is ascertained by experiments of some members of the Academy at Petersburg, induces us to conjecture, that every body is naturally solid or hard; and that all fluid bodies receive their fluidity from fire, which is the only substance essentially fluid.

However that may be, this is evident, that as the aggregation of every body which is fluid or liquid must be broken, or much diminished, fluidity is the most favorable state for the formation of new unions; and that every substance which forms a new combination must necessarily have or acquire this state. Therefore a precise and extensive knowledge concerning fluidity, and the properties of bodies by which they give and receive fluidity, is exceedingly important in chemistry. *See* AGGREGATION, SOLUTION, FIRE, FUSION, *and* LIQUEFACTION.

CCCXII. FLUOR. This word, used as an adjective, is applied to signify the habitual fluidity of any substance, or that property by which a substance cannot be rendered solid, and is employed as an epithet to distinguish such substances from others of the same kind, but which are habitually solid, or which may be rendered solid. Acids, for instance, which are habitually fluid, as all the mineral and some vegetable acids, are called *fluor acids*, in order to distinguish them from the acid of tartar and acid essential salts, which are naturally concrete. Also volatile alkali treated with quicklime, or with metallic earths, so that it is always liquid and not crystallized, is called *fluor volatile alkali*, to distinguish it from the concrete and crystallizable volatile alkali.

By *fluor*, used substantively, is meant a certain kind of stone which is fusible, or which facilitates fusion. Such are the greatest part of *spars*, which are called fluors. Thus, for example, in talking of a white or colored spar, which is found in the matrix of an ore, we say that this matrix is mixed with a white, green, or yellow fluor. *See* SPAR. *(f)*

(f) FLUORS. Mineralogists differ very much [illegible] ; [illegible] the name [illegible] quartz crystals, called also false [illegible], false rubies, &c. *See* CRYSTALS [illegible] crystallized [illegible] [illegible] transparent [illegible] [illegible] all stones possessing the following properties may be properly referred, whether they be transparent or opake, colored or not colored, crystallized or possessing no determinate form. 1. They are not sufficiently hard to strike fire with steel. By this property the colored quartz crystals are excluded.

2. They are not soluble by acids.

3. They have not the distinguishing properties of gypseous or of argillaceous earths.

4. They are fusible by fire without addition. Pott, Cronstedt, and others say, that they are not fusible; but Mr. Engelstom, the Translator of Cronstedt's Mineralogy, affirms, that he has fused all the fluors which he has tried by means of a blow-pipe; and Mr. D'Arcet found, by his experiments, that

CCCXIII. **FLUX.** This word is sometimes used synonimously with *fusion*. For instance, an ore, or other matter, is said to be in liquid flux, when it is completely fused.

But the word flux is generally used to signify certain saline matters, which facilitate the fusion of ores, and other matters which are difficultly fusible, in essays and reductions of ores. Fixed alkalis, nitre, borax, tartar, and common salt, are the saline matters of which fluxes are generally composed. But the word *flux* is more particularly applied to mixtures of different proportions of only nitre and tartar; and these fluxes are called by particular names, according to the proportions of these ingredients, as we shall see in the following articles.

CCCXIV. **FLUX (WHITE).** White flux is made with equal parts of nitre and of tartar detonated together, by which they are alkalised. The residuum of this detonation is an alkali composed of the alkalis of the nitre and of the tartar, both which are absolutely of the same nature. As the proportion of nitre in this mixture is more than is sufficient to consume entirely all the inflammable matter of the tartar, the alkali remaining after the detonation is perfectly white, and is therefore called *white flux*; and as this alkali is made very quickly, it is also called *extemporaneous alkali*. When a small quantity only of white flux is made, as a few ounces, for instance, some nitre always remains undecomposed, and a little of the inflammable principle of the tartar, which gives a red or even a black color to some part of the flux; but this does not happen when a large quantity is made of white flux, because then the heat is much greater. This small quantity of undecomposed nitre and tartar which remains in white flux is not hurtful in most of the metallic fusions in which this flux is employed; but if the flux be required perfectly pure, it might easily be disengaged from those extraneous matters by a long and strong calcination, without fusion. *See* CALCINATION.

CCCXV. **FLUX (CRUDE).** By crude flux is meant the mixture of nitre and tartar in any proportions, without detonation. Thus the mixture of equal parts of the two salts used in the preparation of the white flux, or the mixture of one part of nitre and two parts of tartar for the preparation of the black flux, are each of them a crude flux before detonation. It has also been called *white flux*, from its color; but this might occasion it to be confounded with the white flux above described. The name therefore of crude [illegible] more convenient.

that they were fusible. I have also, by a very considerable heat, fused some of those white opake fluors, which are said to be similar to the *petunse*, or one of the materials of which the Chinese compose their porcelain.

5. With much more moderate heat they greatly facilitate the fusion of calcareous and argillaceous earths, and of the topaz, according to Mr. Pott. For which quality they have been much employed in the fusi-

ing of ores, as they [illegible] the adhering earths.

6. When heated [illegible]

Crude

Crude flux is detonated and alkalised during the reductions and fusions in which it is employed, and is then changed into white or black flux, according to the proportions of which it is composed. This detonation produces good effects in these fusions and reductions, if the swelling and extravasation of the detonating matters be guarded against. Accordingly, crude flux may be employed successfully in many operations; as, for instance, in the ordinary operation for procuring the regulus of antimony.

CCCXVI. FLUX (BLACK *or* REDUCING). Black flux is produced from the mixture of two parts of tartar and one part of nitre detonated together. As the quantity of nitre which enters into the composition of this flux is not sufficient to consume all the inflammable matter of the tartar, the alkali which remains after the detonation contains much black matter, of the nature of coal, and is therefore called *black flux*.

This flux is designedly so prepared, that it shall contain a certain quantity of inflammable matter; for it is thereby capable not only of facilitating the fusion of metallic earths like the white flux, but also of reviving these metals by its phlogiston. From this property it is also called reducing flux; the black flux, therefore, or crude flux made with such proportions of the ingredients as to be convertible into black flux, ought always to be used when metallic matters are at once to be fused and reduced, or even when destructible metals are to be fused, as these require a continual supply of phlogiston to prevent their calcination. *See* NITRE, REDUCTION, *and* TARTAR.

CCCXVII. FORGE. An ordinary forge is nothing but a pair of bellows, the nozzle of which is directed upon a smooth area, on which coals are placed. The nozzle of a pair of bellows may be also directed to the bottom of any furnace, to excite the combustion of the coals placed there, by which a kind of forge is formed. In laboratories, there is generally a small furnace consisting of one cylindrical piece, open at top, which has at its lower side a hole for receiving the nozzle of a double bellows. This kind of forge-furnace is very convenient for fusions, as the operation is quickly performed, and with few coals. In its lower part, two inches below the hole for receiving the nozzle of the bellows, may be placed an iron plate of the same diameter, supported upon two horizontal bars, and pierced near its circumference with four holes diametrically opposite to each other. By this disposition, the wind of the bellows, pushed forcibly under this plate, enters at these four holes; and thus the heat of the fire is equally distributed, and the crucible in the furnace is equally surrounded by it. This contrivance is used in the forge-furnaces for melting copper, with this difference only, that these furnaces are square, which is a matter of no consequence.

As the wind of bellows strongly and rapidly excites the action of the fire, a forge is very convenient when a great heat is to be applied quickly; but it is not suitable when the heat is to be gradually increased.

The forge, or blast of bellows, is used in several operations in small; as, to fuse [illegible], &c. It is also much used in works in the great, which require a strong heat, without much management, and chiefly in the smelting of ores, and fusion of metallic matters.

CCCXVIII. FRITT. Fritt is a mixture of several substances intended to be fused together for the purpose of making glass. After these substances have been

been mixed together, they are generally exposed during a certain time to a more or less strong heat, which is, however, incapable of compleatly fusing them. The intention of this operation is either to effect a slight union betwixt these matters, or to free them more perfectly from any inflammable or extraneous matter, by this calcination. *See* VITRIFICATION.

CCCXIX. FRUITS. (g)

CCCXX. FULIGINOSITY. By this word is meant soot, or the black matter which accompanies the flame of oils and of oily substances. *See* SOOT.

CCCXXI. FULMINATION. Fulmination is the sudden and violent explosion and inflammation of certain bodies, which are therefore called *fulminating*. Such are the explosions of fulminating powder and of fulminating gold. The explosion of these matters is called *fulmination*, from the noise accompanying it, by which it resembles thunder.

CCCXXII. FURNACE. Furnaces are chemical instruments used for containing combustible matters, by the burning of which the heat requisite for operations is procured; and also for containing the substances themselves to which the heat ought to be applied.

As chemists require for different operations all the possible degrees of heat, from the weakest to the strongest, and as the form of furnaces contributes greatly,

(g) FRUITS are considered only as *coloring materials* in this article, the greatest part of which is extracted from a note of Dr. Lewis to his Translation of Neuman. The red juices of fruits, as of *currants, mulberries, elder berries, morello and black cherries*, when inspissated and dried, may be again dissolved in water, to which they give nearly the same red color as they do when fresh. Rectified spirit extracts the tinging particles, and acquires a brighter color than the watery solution; because much of the mucilage is left undissolved by the former. The red solutions and the juices are sometimes made dull, and sometimes more florid, by acids, and are generally rendered purplish by alkalis. The colors of these juices are generally perishable. They are not destructible by the fermentation of the liquors, but they quickly decay when the juice is spread thinly on any substance, and dried in open air. The bright lively reds are soonest changed. The dark, dull red stain of the black cherry is considerably durable. The bright red fruit of the *opuntia* or *prickly pear* is an exception to the above rule; as it gives, according to Labat, a beautiful red dye. The ripe berries of *buckthorn* stain paper of a green color. From these is prepared the substance called *sap-green*, which is a pigment sufficiently durable, soluble in water, but not miscible with oil. The same berries dried whilst green, and macerated in alum-water, are said to yield a yellow pigment, and when they have grown over-ripe, a purple pigment. Woollen cloth, prepared with alum and tartar, receives, on being boiled with the berries, a perishable yellow dye. The *French berries*, or *graine d'Avignon*, one of the most perishable yellow dyes, is a berry of the species of buckthorn. It is said, that the berry of the *heliotropium tricoccum* stains paper of a green color; and that this green is soon changed to a blue; that the common blue paper receives its color from this juice; and that the red rags called *turnsol*, employed for coloring wines and other liquors, are tinctured by the same juice turned red by acids. Mr. Nissole says, that the coloring juice is obtained, not from the berries, but from the tops of the plant. The Dutch are said to prepare their rags from other materials, of which archil is a principal one.

The seeds of some plants, as of *peony*, are covered with a fine shining red membrane. The pellicles of the seeds of an American tree afford the red matter called *annotto*, *orlean*, and *roucou*. *See* ANNOTTO.

greatly, as we ſhall ſee, to produce the different degrees of heat; they have contrived many furnaces of different forms and conſtructions; but all theſe furnaces may be reduced to a ſmall number of general diſpoſitions, which we ſhall now deſcribe.

The *ſimple furnace* is a kind of hollow tower, cylindrical or priſmatical, wit two doors or principal openings; the one below, called the *door of the aſh-hole*; and the other immediately above this, called the *door of the fire-place*. Betwixt theſe two doors a grate is placed horizontally acroſs the interior part of the furnace, dividing the whole cavity of the furnace into two parts: the lower part is called the *aſh-hole*, becauſe it receives the aſhes which fall from the fire-place. The door of the aſh-hole gives admittance to the air neceſſary for maintaining the fire within the furnace. The upper cavity of the furnace is called the *fire-place*, becauſe it contains the combuſtible matters. Through the door of the fire-place, freſh fuel is to be introduced, to ſupply the place of what is conſumed.

This ſimple furnace, ſimilar to that uſed in kitchens, is ſufficient for many chemical operations. In the fire-place, amidſt the coals, crucibles may be placed for the fuſion of fuſible matters; ſuch as lead, tin, biſmuth, &c. or for the calcination of matters which require but little heat for their calcination; ſuch as the alkali for making Pruſſian blue, bezoar mineral, &c.

On this furnace may alſo be placed baſons for evaporations, alembics for diſtilling in the water-bath, pots filled with ſand for digeſtions and diſtillations to be performed by means of a ſand-bath and a gentle heat, either with alembics or with retorts.

As ſeveral of the operations made with this furnace are of long duration, and as the furnace requires a continual ſupply of fuel; chemiſts have contrived to adapt to it a magazine of coals in form of a hollow tower, cloſed in its upper part, and ſo diſpoſed, that while the coal of the fire-place is conſumed, that of the tower falls down and ſupplies its place. The furnace thus diſpoſed is called an *athanor*, or the *furnace of ſluggards*. *See* ATHANOR. *See* PLATES.

The *lamp-furnace* is a kind of athanor, in which the heat is produced and maintained by the flame of a lamp introduced within it. This furnace has evidently no occaſion for an aſh-hole, a grate, or a fire-place. It has only one opening below, through which the lamp is introduced, and a kind of ſmall chimney made in its upper and lateral part, for circulation of air, to keep up the flame of the lamp, and to give vent to the ſmoke. This furnace is very convenient for diſtillations which require little heat. A water-bath or ſand-bath may be fitted to it. It is particularly uſeful for digeſtions. *See* PLATES.

The *reverberatory furnace* is the ſimple furnace, the fire-place of which is covered with a piece of the ſame diameter and form as the furnace, which is generally cylindrical. This piece is croſſed in its lower part by two bars of iron placed horizontally and parallel to each other, and at its upper edge it has a ſemi-circular cut. This piece conſequently forms a third cavity, which is called the *Laboratory*, becauſe it is intended to receive the retorts containing the matter to be diſtilled. The ſemi-circular cut is made to give paſſage to the neck of the retort, which, as we have ſaid under the article DISTILLATION, ought to be inclined at an angle of 45 degrees. The uſe of the two bars at the bottom of the laboratory is to ſupport the veſſel placed there.

Above the piece we have now described is a fourth piece placed, the form of which is that of a ſpherical cap, or of an inverted dome: it is accordingly called the *dome*. This dome has an equal diameter to the other piece, to which it is to be fitted; and in its lower edge it has a ſemi-circular cut, which correſponds with the ſimilar cut of the lower piece; and theſe together form a circular opening: the dome has in its top another opening or ſhort tube, through which the air contained in the furnace paſſes, and is a kind of chimney.

The uſe of the dome is to keep up the heat all around the retort which is placed in the furnace, and to apply a certain degree of heat to the upper part or vault of the retort, by reflecting or reverberating it: hence it is called a *reverberatory*. By this diſpoſition the vapors which riſe in the retort are determined more efficaciouſly to paſs through its neck. We may judge after this deſcription, that reverberatory furnaces are only uſed for diſtillations with a retort, in which a certain degree of heat is neceſſary.

Diſtillation may be performed in reverberatory furnaces, either in naked fire, by placing the retort immediately upon the bars, or in a ſand-bath, by placing upon theſe ſame bars an iron veſſel, in the upper edge of which is a ſemi-circular cut. Into this iron veſſel is put fine ſand to the thickneſs of one or two fingers: then the retort is to be placed in it; and, laſtly, it is to be filled with ſand up to the arch of the retort. If the heat be required to be of a certain ſtrength, the iron veſſel muſt have a diameter ſo much leſs than the internal part of the furnace, that an empty ſpace of about the thickneſs of a finger ſhall be left betwixt them, excepting on the ſide where the neck of the retort is; and there the hollow cuts of the furnace and iron veſſel that correſpond to each other ought to join exactly. *See* Plates.

The *melting furnace*, or wind furnace, is intended to produce the greateſt degree of heat that can be excited without bellows. This furnace ought to be ſo conſtructed, that a current of air ſhall conſtantly paſs through the fire-place; and the more ſtrongly and rapidly this air paſſes, the more intenſe will be the heat in the furnace.

The chief method for producing this effect is to leave in the upper part of the furnace a ſpace cloſe on every ſide, excepting above and below; becauſe the air contained in this cavity being rarefied and expelled by the heat produced by the fuel burning in the furnace, a vacuum is here formed, which the external air neceſſarily tends to occupy from its gravity.

This being eſtabliſhed, the furnace ought evidently to be ſo diſpoſed that the external air ſhall be obliged to enter at the aſh-hole, and to paſs through the fire-place, to fill the vacuum which is continually forming both in the internal part of the furnace and in its upper cavity.

We ought to obſerve, that the column of air which correſponds with the upper part of the furnace, being a little ſhorter, and conſequently lighter, than the column which correſponds with the lower part, the air appears naturally determined to enter at the bottom, and to go out at the the top of the furnace; ſo that if this furnace was a hollow cylinder, the lower and upper mouths of which were equal, and if the fire-place was in the middle, the air would probably paſs through it from bottom to top; but this difference of the two columns being almoſt infinitely ſmall, the velocity of the current of air would be as ſmall: but if, inſtead of this diſpoſition, the furnace be contracted in its upper part, and if it be made to become a tube of leſs diameter, then the rarefied air

is obliged considerably to accelerate its course in passing through a straiter space and thereby overcomes more easily the pressure of the superior air: hence the air introduced through the lower part of the furnace, in order to fill the vacuum which is continually forming in its upper part, passes so much more rapidly through the fire-place as it finds less obstacle above; and consequently this disposition of the furnace necessarily determines a strong and rapid current of air to pass through it, from the bottom to the top.

From what has been said we may easily perceive, that the more the space or air is rarefied in the upper part of the melting furnace, the stronger and more rapid is the external current of air which is obliged to enter the furnace to fill up this vacuum; and consequently the more intensely the coals must burn. Hence these furnaces produce so much more heat, as the tube which is at their upper part, called the *tube of aspiration*, is longer. But we must observe, that although the activity of this furnace is owing in great measure to the contraction in its upper part or to its tube; nevertheless a too great contraction of the tube would be very inconvenient, because the air rarefied, and obliged to go out at the upper part, can only acquire a certain determinate velocity: whence it follows, that if this tube, through which the rarefied air is to go out, were so strait that this air could not pass, unless it had a greater velocity than it is capable of acquiring, then the air, finding an obstacle in its way, would be retarded in its progress; and consequently too great straitness in the tube impedes rather than facilitates the course of the air: accordingly, I have found by experience, that a melting furnace to which too strait a tube, however long, has been adapted, produces little effect, compared with that caused by a tube of sufficient diameter.

Hence the diameter of the tube must have a certain relation to the capacity of the furnace, and to the door of the ash-hole. I have found that the diameter of the tube ought to be to the diameter of the furnace as 2 to 3 nearly, particularly when the tube is long enough (*b*). The opening at the bottom of the furnace may be equal in width to the body of the furnace, or it may be contracted, if the air be required to strike the fire with more force and rapidity. After all these principles, we now proceed to the construction of a good melting furnace. The body of this furnace does not differ from that of a simple furnace, except that it is, or may be open, or almost

(*b*) The diameter of the tube ought to have a certain proportion, not to the door of the ash-hole, but to the space left by the intervals of the grate; and both these ought to bear a certain proportion to the diameter of the fire-place. The proportion mentioned by the Author, which the diameter of the tube should hold to the diameter of the fire-place, as two to three, seems to allow too great a width to the tube. When the tube is too wide, more air passes through the furnace than is necessary for the maintenance of the fire and consumption of the fuel; by which means the furnace is greatly cooled; and even, if the air should be prevented from passing through in too large a quantity, by narrowing the door of the ash-hole, the air will pass down the wide tube, which will then contain two distinct columns of air, one ascending, and the other descending. The following proportions seem to me to be preferable: If the area of the fire-place contain 144 square inches, let the area of the tube, and the sum of the several intervals of the grate be, each of them, 36 square inches: but in certain states of the fire, for instance, when it is thoroughly kindled, the upper vent may be advantageously still further contracted by registers, by which much fuel may be saved, and the fire kept more equally intense.

entirely open, below, and supported upon feet, or a kind of tripod, which serves as an ash-hole. An elliptical form is generally given to it, with intention to concentrate the heat *(i)*. The upper part of this furnace is terminated by a dome higher than that of the reverberatory furnace, called the *cap*. This cap has two openings, one of which is placed laterally and in the front; it ought to be large, and to be capable of being closely shut by a door: the other is at the top, and ought to be a tube of a convenient diameter, upon which other tubes of indeterminate length are adjusted.

This furnace has no laboratory, or rather its laboratory is the fire-place itself; for the matters to which the heat is to be applied are placed in the fire-place, and surrounded by the burning coals.

The melting furnace may have a door to the fire-place; but this door ought to be kept shut during the operations. It only serves for the more convenient examination of the condition of the crucibles or other matters placed in the furnace, and not for the introduction of fresh fuel, for which purpose the door of the cap is intended. This latter door ought to be very large, that a considerable quantity of coal may be thrown in at once. The reason why this door is preferable to the door of the fire-place for the introduction of the fuel is, that the current of air may not be disturbed in its direction; and therefore the lateral door ought to be kept open as little as possible.

When the internal diameter of such a furnace is 12 or 15 inches, when the diameter of the tube is 8 or 9 inches, and its height 18 or 20 feet, and when the furnace is well supplied with fuel, an extreme heat is produced: in less than an hour the fire will be white and dazzling, like the sun: its heat will be equal to the strongest degree of heat in a glass-house furnace. In less than two hours may be melted whatever is fusible in furnaces *(k)*. The hottest part of this furnace is 4 or 6 inches above the grate.

Chemists generally believe that the power of a melting furnace is greatly encreased by a wide and high ash-hole, or by bringing the air which is to enter it through a long pipe from without the house in which the furnace stands: but these advantages are either imaginary, or only relative to the vacuum formed in the upper part of the furnace. If indeed a furnace be so placed that the opening of its ash-hole shall be fitted to the mouth of a great cavity; as to a cave, for instance, in the roof of which a hole is made, into which this furnace is to be fitted; and if this cave has no other opening than through the bottom of the furnace; then a very strong current of air will pass from the cave across the furnace, although the furnace had neither cap nor tube: but we must observe, that this current of air will always be stronger if the furnace is provided with a dome and tube; and secondly, if the air be determined to pass from the cave across the furnace, even without dome or tube, this must proceed

(i) The inequality of the surface of the sides of the furnace would prevent any advantage from the elliptical form of furnaces, even if heat were supposed to diffuse itself, like light, only in right lines, and to be thereby capable of concentration by reflexion; a supposition, however, which cannot be admitted.

(k) Most fusible substances may be fused in a much less time: nevertheless we find from M. D'Arcet's Memoir concerning the effects of a violent and long-continued heat, that by prolonging the action of fire, he had been able to vitrify substances which had resisted the most violent fires continued only during a shorter time.

only from the heat of the furnace rarefying the ambient air, by which the more condensed air of the cave is determined to pass through the furnace to supply the place of this rarefied air. In this case, the chamber in which the furnace is placed, serves instead of the dome and tube. This happens in a glass-house furnace. These furnaces are built upon subterranean vaults, which serve as ash-holes. The internal capacity of these furnaces is very great, and is occupied only partly by the combustible matters, and by the pots containing the glass: hence the air of the ash-hole is continually introduced there to fill this empty space: besides, the heat is always very great in the domes under which the furnaces are built; the contained air is therefore continually rarefied; so that they serve as the domes and tubes of furnaces to draw the air from the vaults.

The pipe which is sometimes fitted to the ash-hole of melting furnaces does not contribute to the draught of the furnace, excepting the laboratory in which the furnace stands be small and confined: for then the air of this laboratory, being soon heated and rarefied, becomes less proper for exciting fire than the colder external air which the pipe supplies. *See* PLATES.

The furnace called the *essay* or *cupelling furnace* is of a prismatic quadrangular figure, and is chiefly used to make essays of the value of silver, or of silver ores. This furnace is composed of an ash-hole, a fire-place, and an upper part which terminates it above, like a quadrangular truncated pyramid. The fire-place and ash-hole are not, properly speaking, separated from each other, because this furnace has no grate (*l*); hence the coals in this furnace fall to the bottom: in the lower part of the furnace are three small doors, two in the sides, and one in the front: above this latter door is a fourth door, placed like that of the fire-place of a simple furnace; and at the bottom of this door are two iron bars, placed within the furnace horizontally and parallel to each other. These bars are intended to support a muffle, the mouth of which corresponds exactly to the last mentioned door. In this muffle the cupels and vessels capable of containing the matter to be heated are to be placed.

The top of this furnace is truncated, and forms a pretty large aperture, through which the fuel is to be introduced. Some of these furnaces have a small hole in the front of this upper part, through which an iron rod is introduced to push the coals down, and which also serves to shew the state of the fire. In some of these furnaces the upper part is terminated by a short tube, which on some occasions is convenient; for although the internal capacity of this furnace, including its upper part, makes a sufficient draught for these operations, a greater heat may possibly be required, and this is effected by adapting a tube to this furnace. *See* ESSAYS.

Some operations, which must be made either in a muffle or in a reverberatory furnace, require the strongest melting heat. The distillation of Kunckel's phosphorus, for instance, requires a heat much superior to that of ordinary distillations. Essays also of porcelain and vitrification, which ought to be done very cleanly, and therefore under a muffle, require a very violent heat, which cannot be procured in an ordinary essay furnace. In these cases a tube may be fitted to the distilling

(*l*) A grate would certainly render this furnace much more convenient; in the plate therefore which we have added of this furnace a grate is represented.

or

or to the essay-furnaces, like that of the melting furnace; and thus as strong a heat as is wanted may be procured. *See* Phosphorus, Porcelain, Vitrification. *(m)*

Chemists have contrived many other furnaces, and some very complicated, for particular purposes; but they are mostly embarrassing, ill-contrived, and even useless: for by the furnaces above described an able operator may perform perfectly well every chemical operation.

All these furnaces may be either portable, and composed of baked earth hooped with iron rings, or covered with iron plates, if they are intended to be more durable; or they may be fixed and stationary, and made of bricks and tiles. This depends on the size and disposition of the laboratory.

The matter of all chemical furnaces is always a clay which ought to be of a good quality. Common clays do well enough for furnaces that are not intended to sustain very violent heats, by which furnaces are apt to be cracked and destroyed, even before the operation is finished, unless they are made of the most pure and refractory clay. *See the clays most proper for this purpose under the article* Clay.

In these furnaces no iron bars or supports ought to be used, as that metal is very quickly melted, calcined, and destroyed. All the supports within these kinds of furnaces ought to be of the same clay of which the furnace consists. As the heat is much less in the tube than in the body of the furnace, this tube is frequently made of iron plates, excepting its lower part, which ought always to be made of clay. These tubes of iron plate have many advantages, as they are light and manageable; but they have a great inconvenience, which is, that their inner surfaces are subject to calcine; hence when much flame passes through them, scales fly off from the iron with noise; which falling upon the crucibles and muffles, dispose them to vitrify, because iron is a powerful flux to clay. The whole tube ought therefore to be made of clay.

When the tube is long, it ought to be strengthened by iron rings and hooks; but these ought to be so arranged that the tube may be lengthened and shortened, according as the greater or less heat may dispose it; otherwise it might crack.

The furnaces described in this article are employed, and are necessary, for the several operations of chemistry. Many of them are also used in the arts, in manufactures, and in works in the great: such are the furnaces for glass, pottery, porcelain, and for smelting of ores. What is peculiar to any of these furnaces may be found under the article of the art in which it is employed. In other respects their structure is conformable to the general principles established in the present article. *(n)*

CCCXXIII. **FUSIBILITY.** Fusibility is a quality which renders bodies susceptible of becoming fluid, when exposed to a certain degree of heat.

(*m*) See a plate and description of a very commodious furnace for experiments on vitrification, and on the making of porcelain, and for many other purposes.

(*n*) *See* Plates, where several furnaces are represented, and the descriptions annexed; in which the proper compositions for lining the insides of furnaces made of plated iron, and the methods of applying them, are related.

Fusibility is the reverse of the refractory quality; so that the less the heat is which is requisite for the fusion of any substance, the more fusible it is.

Bodies differ much from each other as to their degrees of fusibility. Some of them, as air and mercury, are so fusible that the heat of the atmosphere is always sufficient to keep them fluid; others, as some oils and water, which are naturally solid with the degree of cold marked 0 in Reaumur's thermometer, are presently melted when they are exposed to a greater heat: other substances again, as lead, tin, bismuth, &c. are habitually solid in the greatest natural heats; but are fusible with a degree of heat less than is requisite to make them red: and, lastly, others are not fusible till they become red, and even white, by heat: such are silver, gold, copper, iron, glass, &c.

As the fusion of a body is caused by the interposition of fire betwixt its integrant parts, by which their adhesion is destroyed, we cannot conceive any other cause of the greater or less fusibility than a more or less intimate contact, and a more or less strong adhesion of the integrant parts of different bodies; which are dispositions depending on the figure of these parts. *See* HARDNESS *and* FLUIDITY.

CCCXXIV. FUSION. Fusion is the state of a body rendered fluid by fire. *See* FLUIDITY *and* FUSIBILITY.

G.

CCCXXV. GALANGAL. (o)
CCCXXVI. GALBANUM. (p)
CCCXXVII. GALLEY. This name is given to reverberatory furnaces, in which several retorts may be placed at the sides of each other. As these furnaces are oblong, and have lateral openings, they have been supposed to resemble galleys, and have thence received their name.
CCCXXVIII. GALENA. (q)
CCCXXIX. GALLS. (r)

(o) GALANGAL. The Indian root called *greater galangal* resembles ginger in smell, taste, and chemical composition. The *smaller galangal* has a stronger and more agreeable smell than the former, and a more pungent and hot taste, like that of pepper. From 16 ounces of this root scarcely two scruples of oil were obtained; and this oil possesses little of the pungency of the root. Six ounces of extract were obtained by means of water from 16 ounces of the root; and an ounce and a half from the same quantity by means of spirit of wine. The watery extract was the more pungent of the two. *Neuman.*

(p) GALBANUM is a gum-resin, containing more of a resinous than gummy matter. Spirit of wine extracted from a pound of it nine ounces and a half, and water extracted from the same quantity only three ounces. The smell, flavor, and peculiar taste of galbanum resides in an essential oil, which may be raised in distillation either by means of water or of spirit of wine. From a pound of galbanum six drams of essential oil may be obtained. This oil, or a great part of it, is of a blue color, sometimes of a deep bright blue. By exposure to air this blue color is changed to a purple. *Neuman.*

(q) GALENA is the name of a lead ore, consisting of cubic particles, and composed of lead mineralised by sulphur, with which also a little silver is almost always united. *See* ORES *of* LEAD.

(r) GALLS are excrescencies found upon oak trees, and are amongst the strongest vegetable astringents. Extracts made from galls, either by water or by spirit, possess all the astringency of these vegetable substances. From sixteen drams of galls fourteen drams were extracted by water; and from the same quantity twelve drams and two scruples were extracted by spirit. Galls, like other vegetable astringents, or the infusions of these substances, being added to solutions of green vitriol, or to dilute and saturated solutions of iron in any acid, change the color of these solutions to a deep blue or black. The black liquor thus produced is the basis of inks, and of many black dyes. *See* BLACK *and* INK. When the green vitriol is dissolved, and when the galls are infused in distilled water, or in common spring waters, the color produced by mixing them is, according to Dr. Lewis, blue: but if the smallest portion of alkaline salt be dissolved in the water, or if this water has any putrid tendency,

CCCXXX. GAMBOGE. (*s*)

CCCXXXI. GANGUE. Gangue is the matrix of ores. *See* MATRIX.

CCCXXXII. GARLIC. (*t*)

CCCXXXIII. GARNET. (*u*)

CCCXXXIV. GAS. This name is given by chemists to the volatile in-

tendency, however small, the color produced will be purplish or reddish. These colors, when rendered more intense, by adding more of the coloring substances to the water, appear of a black color. The blackness produced by this mixture proceeds from a coloring matter which is only diffused through the liquor, and may be separated from thence by dilution with water, and by deposition. The separation may be prevented, as is done in the preparation of ink, by adding some mucilaginous matter, as gum arabic. This coloring matter is evidently a ferruginous precipitate; for altho' it is not magnetical, it may be rendered magnetical by a slight calcination. To this precipitate some of the inflammable matter of the vegetable astringent adheres and gives color. When by calcination this adhering matter is made to combine in some measure with the ferruginous precipitate, this precipitate, though not perfectly metallized, is however sufficiently metallized to be rendered magnetical. In these properties this precipitate corresponds with the blue ferruginous precipitate, which forms Prussian blue, to which also some phlogistic matter adheres and gives color; but it differs from Prussian blue by this property, that it is soluble by acids, whereas the latter precipitate is not soluble. Thus, the black coloring matter of inks may be dissolved by acids, and their color thereby destroyed. Alkalis also destroy the blackness of inks, by dissolving the astringent or inflammable adhering matter, and leaving the iron in an ochery state, similar to the precipitates of iron, formed by adding alkalis to solutions of that metal in acids. The blackness destroyed by adding acids to ink is recovered by addition of alkalis; and conversely.

I have not found that galls precipitate other metallic substances; but I have observed, that when added to metallic solutions, the precipitates afterwards formed from these by fixed alkalis, were deeply colored, and generally purple.

(*s*) GAMBOGE is an acrid gum-resin, the gummy parts of which are so intimately blended with the resinous, that greatest part of it is soluble either by water or by spirit of wine. It forms a beautiful yellow pigment, and is much used as such by painters. Dr. Lewis says, that it gives a beautiful and durable citron-yellow stain to marble, whether rubbed in substance on the hot stone, or applied, as Dragon's blood is, in form of a spirituous tincture. When it is applied on cold marble, the stone is afterwards to be heated, to make the color penetrate.

(*t*) GARLIC. The roots of garlic contain a considerable quantity of mucilage, some resin, and a very small portion of essential oil, in which the whole smell, taste, and peculiar qualities of garlic reside. From thirty-two ounces of garlic distilled with water, Neuman could obtain scarcely half a dram of this oil.

(*u*) GARNET, *Granatus gemma*, is a stone ranked amongst those called gems, tho' less brilliant than any other gem; it is transparent, sometimes more and sometimes less; generally of a dark-red color, but sometimes yellowish or brown; the eighth stone in hardness from diamonds; and fusible by fire. Cronstedt forms a distinct order of the garnets and the basaltes, which he calls *terræ granatæ*. The distinguishing property of these garnet earths is, that they are more fusible in proportion as they contain less metallic matter, and are more transparent and glassy in their texture. In other respects they resemble the siliceous order of earths. *See* BASALTES. All garnets contain iron; most of them contain tin also; and some, according to Mr. Swab, contain iron and lead. Their forms are various; some having six sides, and others having a greater number. To imitate garnets Neri directs, that twenty pounds of crystal frit, sixteen pounds of calx of lead, three ounces of manganese, half an ounce of zaffre, should be fused together during twelve hours; and that the vitrified mass, after it is separated from any lead which may have been revived by the fusion, must be again kept in fusion during ten hours.

visible parts which escape from certain bodies, and which cannot be retained and collected, at least without great difficulty, and mixture of other substances.

Thus, for example, the noxious vapors which rise from burning charcoal, and from matters undergoing the spirituous and putrid fermentations, the volatile part of spirituous mineral waters, the spiritus rector of some substances, such as musk, may be called the *gas* of these bodies.

The gas of most substances, particularly those which affect the nerves, seems to be nothing but pure, or almost pure phlogiston, which is disengaged from bodies without ignition. The mineral noxious vapors called *damps* may be also ranked amongst vapors called *gas*, at least those of them may which are invisible. *See* DAMPS.

CCCXXXV. GELATINOUS, *and* GELLY. (x)

CCCXXXVI. GEMS. (y)

CCCXXXVII. GENTIAN. (z)

CCCXXXVIII. GILDING. Gilding is the art of applying exceedingly thin layers of gold upon the surfaces of certain substances, to give them the external appearance of gold.

The lustre and beauty of gold have occasioned several inquiries and discoveries concerning the different methods of applying it to different substances. Hence the art of gilding is very extensive, and contains many particular operations, and various management.

A color of gold is given by painting and by varnishes, without employing gold; but this is a false kind of gilding. Thus a very fine golden color is given to brass and to silver, by applying upon these metals a gold-colored varnish, which being transparent, shews all the brilliancy of the metals beneath. Many ornaments of brass are varnished in this manner, which is called *gold lacquering*, to distinguish them from those which are really gilt. Silver-leaves thus varnished are put upon leather, which is then called gilt leather. (a)

(x) GELATINOUS *and* GELLY. *See* JELLY.

(y) GEMS are certain stones consisting of the *siliceous*, or what is improperly called *vitrifiable* earth, much valued for their lustre, transparency, color, hardness, weight, and rarity. These are, diamonds, rubies, saphirs, topazes, emeralds, chrysolites, amethysts, garnets, hyacinths or jacinths, beryls or aqua marinas. The order in which they are enumerated shows their relative degrees of hardness. See *each of these articles*, DIAMONDS, RUBIES, &c.

(z) GENTIAN. From sixteen drams of the root of gentian Neuman obtained six drams and a half of resinous extract by means of spirit of wine, which contained all the bitterness of the gentian; and from the same quantity he obtained nine drams of gummy extract, which was considerably bitter, but less so than the spirituous extract.

(a) The basis of these lacquers is a solution of the resinous substance, called seed-lac, in spirit of wine. The spirit of wine must be very much dephlegmated, and for this purpose authors direct dry pot-ash to be thrown into it, which attracts the water, and with it forms a liquid distinct from the spirit; which being collected at the bottom of the vessel, may be separated by decanting the spirit. By this method the spirit is much dephlegmated; but, at the same time, it dissolves a part of the alkaline salt, by which it acquires color, and also communicates a property to the lacquer of imbibing moisture from air. These inconveniences are prevented by adding to the spirit of wine thus dephlegmated some calcined alum, the acid of which unites with the alkaline salt remaining in the spirit, and forms with it a vitriolated tartar; which not being soluble in spirit of wine, falls to the bottom, together with the earth of the decomposed alum, and the superfluous alum, if more be added than is necessary. To a pint of the spirit thus dephlegmated,

Amongſt the falſe gildings may alſo be reckoned thoſe which are made with thin leaves of copper or braſs, called *Dutch leaf*. In this manner are made all the kinds of what is called gilt paper.

In the true gilding, gold is applied to the ſurface of bodies. The gold intended for this purpoſe ought in general to be beat into thin leaves, or otherwiſe divided into very fine parts.

As metals cannot adhere well merely by contact to any but to other metallic ſubſtances, when gold is to be applied to the ſurface of ſome unmetallic body, that ſurface muſt be previouſly covered with ſome gluey and tenacious ſubſtance, by which the gold ſhall be made to adhere. Theſe ſubſtances are in general called *ſizes*. Some of theſe are made of vegetable and animal glues, and others of oily, gluey, and drying matters. Upon them the leaves of gold are applied; and when the whole is dry, the work is to be finiſhed and poliſhed. Wood chiefly is gilt in this manner; but it muſt be previouſly covered with ten or twelve layers of chalk, mixed with glue diſſolved in water. That forms a body or coat, which hurts the ſculpture and mouldings upon the wood; but is neceſſary for furniſhing the gold with a ſofter ſupport; otherwiſe, if the gold was applied to the wood without the interpoſition of this ſize, it would be apt to be torn and rubbed off, when burniſhed, that is, poliſhed with a hard inſtrument, called a *dog's tooth*, to give it luſtre. (*b*)

dephlegmated, about 3 ounces of powdered ſhell lac are to be added; and in a day or two, by help of moderate heat, the ſpirit will have acquired a reddiſh color. It ought then to be poured off, ſtrained, and cleared by ſettling: then as much gamboge and arnotto are to be added as are ſufficient to give it the color required, which muſt be diſcovered by frequently trying the mixture upon ſilver leaf. Theſe two ſubſtances are readily ſoluble in the above deſcribed tincture of lac. For the greater conveniency of mixing them in any proportion, the beſt method is to diſſolve them ſeparately in two quantities of the tincture of lac; and thus the color of the lacquer may be adjuſted by mixing together the ſolution of gamboge, which is yellow, with that of annotto, which is reddiſh-yellow. Generally two parts of the ſolution of gamboge are added to one part of the ſolution of annotto. Saffron, dragon's blood, turmeric, and other red and yellow coloring materials, are ſometimes uſed for the ſame purpoſes, but are not preferable to the two above-mentioned. The varniſh is then to be laid, with a bruſh, upon the leaves of ſilver or of tin, previouſly fixed upon the piece of work by the intervention of ſome ſize; and when the varniſh is dry, other layers are to be ſpread till it be ſufficiently thick. A varniſh containing leſs of the coloring materials than the above is applied upon works of braſs to heighten the color, and preſerve it from tarniſhing.

(*b*) When wood, paper, and ſuch ſubſtances are to be gilded, they muſt be previouſly covered with ſome glutinous ſubſtance, upon which, when almoſt dry, gold leaf is to be applied, and preſſed down with a little cotton, or hare's foot. When the matter is dry, the gold is to be burniſhed. When the work is required to be capable of reſiſting rain or moiſture, it ought to be previouſly covered with a compoſition of drying oil and yellow ochre ground together; otherwiſe a water-ſize may be uſed, which is prepared by boiling cuttings of parchment or white leather in water, and by mixing with this ſome chalk or whiting; ſeveral layers of this ſize muſt be laid upon the wood, and over theſe a layer of the ſame ſize mixed with yellow ochre. Laſtly, another mixture, called *gold ſize*, is to be applied above theſe; upon which the gold leaves are to be fixed. This gold ſize, the uſe of which is to make the gold leaf capable of being burniſhed, is compoſed of tobacco-pipe clay, ground with ſome ruddle or black lead, and tempered with a little tallow or oil of olives. The edges of glaſſes may be gilt by applying, firſt, a

The method of applying gold upon metals is entirely different. The ſurface of the metal to be gilt is firſt to be cleaned; and then leaves are to be applied to it, which, by means of rubbing with a poliſhed blood-ſtone and a certain degree of heat, are made to adhere perfectly well. (c)

Gold is applied to metals in ſeveral other manners. One of theſe is by previouſly forming the gold into a paſte or amalgam with mercury. *See* AMALGAM.

With this amalgam the ſurface of the metal to be gilded is to be covered; then a ſufficient heat is to be applied to evaporate the mercury; and the gold is laſtly to be burniſhed with a blood-ſtone. (d)

a very thin coat of varniſh, upon which the gold leaf is to be fixed; and when the varniſh is hardened, may be burniſhed. This varniſh is prepared by boiling powdered amber with linſeed oil in a braſs veſſel to which a valve is fitted, and by diluting the above ſolution with four or five times its quantity of oil of turpentine; and that it may dry ſooner, it may be ground with ſome white lead.

(c) In this manner ſilver leaf is fixed and burniſhed upon braſs in the making of what is called *French plate*, and ſometimes alſo gold leaf is burniſhed upon copper and upon iron.

(d) This method of gilding by amalgamation is chiefly uſed for gilding copper, or an allay of copper, with a ſmall portion of zinc, which more readily receives the amalgam, and is alſo preferable for its color, which more reſembles that of gold than the color of copper. Of the method of preparing the amalgam of gold, *ſee the word* AMALGAM. The proportion of mercury to gold is generally as ſix or eight to one. When the metal to be gilt is wrought or chaſed, it ought to be previouſly covered with quickſilver, before the amalgam is applied, that this may be eaſier ſpread: but when the ſurface of the metal is plain, the amalgam may be applied directly to it. The quickſilver or amalgam is made to adhere to the metal by means of a little aqua-fortis, which is rubbed on the metallic ſurface at the ſame time, by which this ſurface is cleanſed from any ruſt or tarniſh which might prevent the union or adheſion of the metals. The uſe of the nitrous acid in this operation is not confined merely to cleanſe the ſurface of the metal to be gilt from any ruſt or tarniſh it may have acquired; but it alſo greatly facilitates the application of the amalgam to the ſurface of that metal, in the following manner: It firſt diſſolves part of the mercury of the amalgam; and when this ſolution is applied to the copper, this latter metal having a ſtronger diſpoſition to unite with the nitrous acid than the mercury has, precipitates the mercury upon its ſurface, in the ſame manner as a poliſhed piece of iron precipitates upon its ſurface copper, from a ſolution of blue vitriol. When the metal to be gilt is thus covered over with a thin coat of mercury, it readily receives the amalgam. In this ſolution and precipitation of mercury, the principal uſe of the nitrous acid in the proceſs of gilding appears to me to conſiſt. The amalgam being equally ſpread over the ſurface of the metal to be gilt, by means of a bruſh; the mercury is then to be evaporated by a heat juſt ſufficient for that purpoſe; for if it be too great, part of the gold may alſo be expelled, and part of it will run together, and leave ſome of the ſurface of the metal bare: while the mercury is evaporating, the piece is to be, from time to time, taken from the fire, that it may be examined, that the amalgam may be ſpread more equally by means of a bruſh, that any defective parts of it may be again covered, and that the heat may not be ſuddenly applied to it: when the mercury is evaporated, which is known by the ſurface being entirely become of a dull yellow color, the metal muſt then undergo other operations by which the fine golden color is given to it. Firſt, the gilded piece of metal is rubbed with a ſcratch-bruſh, (which is a bruſh compoſed of braſs wire) till its ſurface is made ſmooth; then it is covered over with a compoſition called *gilding wax*, and is again expoſed to the fire till the wax be burnt off. This wax is compoſed of bees-wax mixed with ſome of the follow-

ing

Finally, ſome metals, particularly ſilver, may be gilt in the following manner:

Let gold be diſſolved in aqua regia. In this ſolution pieces of linen are to be dipt, and burnt to black aſhes. Theſe aſhes being rubbed on the ſurface of the ſilver by means of a wet linen rag, apply the particles of gold which they contain, and which by this method adhere very well. The remaining part of the aſhes is to be waſhed off; and the ſurface of the ſilver, which in this ſtate

ing ſubſtances; red ochre, verdegriſe, copper-ſcales, alum, vitriols, borax. By this operation the color of the gilding is heightened; but muſt be further improved by another operation. This conſiſts in covering over the gilt ſurface with a ſaline compound; in expoſing it thus covered to heat till the ſaline matters acquire a certain color and appearance, known to artiſts; and laſtly, in ſuddenly quenching it when thus brought to its proper degree of heat, in urine, water, or other liquid. Different artiſts uſe different receipts for the preparation of the ſaline compound; but all, or moſt of theſe receipts contain nitre, ſal ammoniac, or common ſalt, alum, or ſome vitriolic ſalt; to which they add verdegriſe, borax, or other matters; all which muſt be powdered and mixed, or boiled, with urine. Some artiſts think that they give an additional luſtre to their gilt work, by dipping it after it has undergone the foregoing operations in a liquor prepared by boiling ſome yellow material, as ſulphur, orpiment, or turmeric, in water or in urine, together with tartar, common ſalt, and other ſaline ſubſtances. Theſe operations cannot be well explained, unleſs experiments were made to diſcover by what of the numerous ſubſtances uſed at the ſame time, the effects are produced. In the mean time, I will hazard ſome conjectures concerning this ſubject. The effect produced by flaming off the gilding wax is the heightening of its color; and ſeems to me to be cauſed by a more thorough diſſipation of ſome mercury remaining after the firſt evaporation of it, which is well effected by this equable application of heat. The effect produced by the ſaline compound is that of giving the genuine color of gold, entirely ſimilar to that of a piece of gold dipped in aqua regia, by which any tarniſh upon its ſurface is diſſolved, and its true color is made to appear. Accordingly, in all the receipts which I have ſeen for the preparation of this ſaline compound, I have always found one ingredient to be nitre, another to be common ſalt or ſal ammoniac, and a third to be alum or ſome vitriol. Now, by expoſing theſe to the fire, an aqua regia is actually produced, the vitriolic acid of the alum or of the vitriolic ſalt decompoſing the other two ſalts containing the marine and nitrous acids; by which means theſe acids are ſo diſengaged that they can, thus formed into an aqua regia diſſolve ſome of the ſurface of the gold, and thus give it its genuine color. This action of the marine and nitrous acids upon the gold muſt evidently be continued but an exceeding ſhort time; the artiſt therefore watches the appearance of the ſaline compound, which, from the urine or other ſubſtance containing ſome inflammable matter, becomes black, upon the application of a certain degree of heat; and then he quickly plunges it in water. Laſtly, the only advantage from the laſt operation is, that a part of the yellow matter, as the ſulphur, or turmeric, remains in ſome of the hollows of the carved work, in which the gilding is apt to be more imperfect, and to which it gives a rich and ſolid appearance.

Iron cannot be gilt by amalgamation, unleſs, as it is ſaid, it be previouſly coated with copper by dipping in a ſolution of blue vitriol. Iron may alſo receive a golden coat from a ſaturated ſolution of gold in aqua regia, mixed with ſpirit of wine, the iron having a greater affinity with the acid, from which it therefore precipitates the gold. Whether any of theſe two methods be applicable to uſe, I do not know; but the method commonly employed of fixing gold upon iron is that above-mentioned, of burniſhing gold-leaf upon this metal when heated ſo as to become blue; and the operation will be more perfect if the ſurface has been previouſly ſcratched or graved.

Another

does not ſeem to be gilt, is to be burniſhed with a blood-ſtone, till it acquire a fine color of gold. This method of gilding is very eaſy, and conſumes a very ſmall quantity of gold. Moſt gilt ornaments upon fans, ſnuff-boxes, and other toys of much ſhow and little value, are nothing but ſilver gilt in this manner.

Gold may alſo be applied to glaſs, porcelain, and other vitrified matters. As the ſurface of theſe matters is very ſmooth, and conſequently is capable of a very perfect contact with gold leaves, theſe leaves adhere to them with ſome force, although they are not of metallic nature. This gilding is ſo much more perfect, as the gold is more exactly applied to the ſurface of the glaſs. The pieces are then to be expoſed to a certain degree of heat, and burniſhed ſlightly to give them luſtre. (e)

Theſe are the principal methods of gilding. *Silvering* is performed by proceſſes very ſimilar to theſe, and founded on the ſame principles. (f)

CCCXXXIX. GILLA VITRIOLI. This name is given to white vitriol purified by cryſtallization, which was formerly given as an emetic, from half a ſcruple to a dram. *See* VITRIOL.

CCCXL. GINGER. (g)

Another method is mentioned by authors of gilding upon metals, and alſo upon earthen ware, and upon glaſs; which is, to fuſe gold with regulus of antimony, to pulverize the maſs which is ſufficiently brittle to admit that operation, to ſpread this powder upon the piece to be gilt, and expoſe it to ſuch a fire that the regulus may be evaporated, while the gold remains fixed. The inconveniencies of this method, according to Dr. Lewis, are, that the powder does not adhere to the piece, and cannot be equably ſpread; that part of the gold is diſſipated along with the regulus; that glaſs is fuſible with the heat neceſſary for the evaporation of regulus of antimony; and that copper is liable to be corroded by the regulus, and to have its ſurface rendered uneven.

(e) A more ſubſtantial gilding is fixed upon glaſs, enamel, and porcelain, by applying to theſe ſubſtances powder of gold mixed with a ſolution of gum arabic, or with ſome eſſential oil, and a ſmall quantity of borax; after which a ſufficient heat is to be applied to ſoften the glaſs and the gold, which is then to be burniſhed. With this mixture any figures may be drawn. The powders for this purpoſe may be made, 1. By grinding gold leaf with honey, which is afterwards to be waſhed away with water; 2. By diſtilling to dryneſs a ſolution of gold in aqua regia; 3. By evaporating the mercury from an amalgam of gold, taking care to ſtir well the maſs near the end of the proceſs; 4. By precipitating gold from its ſolution in aqua regia by applying to it a ſolution of green vitriol in water, or ſome copper, and perhaps ſome other metallic ſubſtances.

(f) *Silvering* by amalgamation is ſeldom practiſed, as it does not ſucceed nearly ſo well as the gilding by amalgamation. The common method of ſilvering metals, as braſs, or of making French plate, is that mentioned above of burniſhing ſilver leaves, from twenty to ſixty, upon the piece of metal previouſly heated.

(g) GINGER. From ſixteen ounces of the *root* of common ginger, about a dram of oil poſſeſſing the ſmell and flavor, but not the pungency of the ginger, may be obtained by diſtillation. The ſame quantity of root yielded with rectified ſpirit an ounce and two ſcruples of reſinous extract, containing all the pungent matter of the root. Water alſo extracted four ounces from ſixteen ounces of the root. The watery extract was conſiderably pungent, but it ſeems to receive its pungency from ſome part of the reſin which is mixed with it; for the reſin remaining in the root after the extraction by water, contains greateſt part of the pungent matter. *Neuman.*

CCCXLI. GLACIES MARIÆ. (b)

CCCXLII. GLASS Glass is a hard, solid, brittle, transparent substance. It resists, when it is of a good quality, the action of air, water, acids, and all other menstruums. Lastly, it is not fusible without a very strong heat.

The large quantity of vitrifiable earth which enters into the composition of glass, gives it all these qualities. But as this earth is so difficultly fusible, when it is pure, that it cannot be fused and vitrified by the greatest fires of our furnaces, other matters, and particularly salts, must be mixed with it, by which its fusion is facilitated, and so intimate an union is formed, that it makes with them but one body. These fluxes therefore enter into the composition of glass. We only give here the definition of glass, and refer to the article VITRIFICATION for what we have to say on this important subject.

CCCXLIII. GLASS of ANTIMONY. The method of preparing glass of antimony, is by calcining crude antimony with a moderate heat till no more vapors of sulphur rise, and till it be reduced to a grey ash-colored earth or calx. This calx is then to be put into a crucible, placed in a good melting furnace, and a sufficiently strong heat is to be applied during an hour, or an hour and an half, or rather till it be converted into a transparent glass. The operation may be known to have been well made, by dipping an iron rod into the crucible. In that case, some vitrified matter will adhere to the end of the iron rod, and will be capable of being drawn out into fine wire, like ordinary glass. The crucible is then to be taken from the furnace, and the glass is to be cast upon a smooth plate of copper, which ought to have been previously heated to dry it perfectly. This glass, when cold, is of a transparent hyacinthine color, more or less yellow or reddish.

The earths of all metallic matters are disposed to fusion and vitrification, when they still retain a portion of their inflammable principle. If this portion be too large, they may be melted more easily, but the mass will be opake, and more or less approaching the metallic state. If, on the contrary, these earths are too much dephlogisticated, they are so much more refractory, as they have lost more of their phlogiston, and at last become entirely unfusible, at least in the fires of our furnaces, when so much dephlogisticated as to possess only the properties of pure earths. Therefore metallic glass ought to be considered as in a state intermediate betwixt that of metals and of earths. Accordingly the glass of antimony, like all the others, is so much more colored, fusible, heavy, and less transparent, as the antimony employed has been less calcined.

As glass of antimony is chiefly prepared for the purposes of medicine; and as its emetic quality, which is its chief virtue, depends on the quantity of inflammable principle which it retains; this glass, to be well conditioned, ought to be moderately fusible and transparent, of a hyacinthine color, not too clear, nor too deep; lastly, it ought to smoke, while it remains fused.

(b) GLACIES MARIÆ, or *lapis specularis*, is a transparent, laminated, selenitic or gypseous stone. For its properties *see* GYPSUM. Its appearance is very similar to that of talk, but differs from it in this circumstance, that the plates of which talk consists are flexible, while those of glacies mariæ are inflexible. Some of these laminated gypsums have a rhomboidal form, and are then called *selenites*, or *gypseous spar*: others have no determinate form.

When the glaſs is poured out, this ſmoke condenſes partly in white flowers, which fix upon the ſurface of the glaſs and upon the plate of copper.

Hence the eſſential point for making beautiful and good glaſs of antimony is, to give the antimony the preciſe degree of calcination which is neceſſary; which is not very eaſy. Accordingly the operation ſometimes fails; but the exceſs or defect of the calcination may be remedied. If the calx be too fuſible, and if it flow into a fluid matter which is not tranſparent, nor is capable of being drawn out into wire, as glaſs is, we may conclude that the calx has not been ſufficiently calcined. In this ſtate, the fire ought to be diminiſhed, the crucible uncovered, and, after the matter has been allowed to ſmoke during a certain time, the fire may be encreaſed, and a tranſparent glaſs will be obtained. But if, on the contrary, the calx cannot be made to flow or vitriſy well, this ſhows that the calx has been too much calcined. This fault may be remedied by throwing into the crucible about a ſixteenth part of the weight of the calx, of crude antimony, and then fuſing the whole. This ſmall quantity of crude antimony not only gives phlogiſton to the calx, which thereby becomes more fuſible, but alſo ſome mineral ſulphur, which produces the ſame effect; for glaſs of antimony ſeems always to retain a certain quantity of ſulphur.

When the calx of antimony employed for the preparation of this glaſs is evidently of difficult fuſion, a very ſtrong heat ought to be applied quickly; for by being kept long moderately hot in the crucible before it is fuſed, it is more and more calcined, and at laſt rendered unfuſible. Some calxes are ſuppoſed to have been too much calcined for this operation, becauſe they were not expoſed to ſtrong fire ſufficiently quickly.

Glaſs of antimony is more eaſily and perfectly ſoluble in acids, and particularly in oily acids, than the regulus; wherefore, when taken internally, it produces more conſiderable effects as an emetic. For this reaſon alſo, it is combined with cream of tartar for the preparation of *ſtibiated* or *emetic tartar*.

Formerly it was given medicinally without other preparation than levigation. But its uſe has been relinquiſhed by prudent phyſicians from the violence and uncertainty of its effects, which are produced by the ſame cauſes as thoſe explained under the article TARTAR (EMETIC). Nevertheleſs it is given ſucceſsfully by very able phyſicians in ſome diſeaſes, as in the colic of miners. But notwithſtanding the experience which has eſtabliſhed the uſe of it in theſe caſes, probably emetic tartar might be adminiſtered with equal ſucceſs and greater certainty; and, if neceſſary, in more frequent and larger doſes than in ordinary caſes. *See* TARTAR (EMETIC).

CCXLIV. GLASS *of* ANTIMONY CORRECTED *by* WAX. A method has lately been practiſed in England to render the glaſs of antimony milder; and this preparation has been commended as an excellent remedy in dyſenteries, and lochial hemorrhages. It is made by melting a dram of yellow wax in an iron ladle, and by adding to this an ounce of levigated glaſs of antimony, in a fire continued during half an hour, and juſt ſtrong enough to diſſipate almoſt entirely the wax without inflaming it. When the matter is cooled, it appears of a brown color. It is again to be levigated,

levigated, and is called the glaſs of antimony corrected by wax, or *vitrum ceratum antimonii.* The doſe of it is from ſix grains to ten or twelve.

The emetic quality of glaſs of antimony is indeed diminiſhed by this preparation, becauſe the wax evidently furniſhes a certain quantity of phlogiſton, and approximates it more to the ſtate of the regulus, or rather of the liver of antimony, both which are leſs emetic than the glaſs. But this waxed glaſs muſt evidently be ſubject to the inconveniencies of theſe other preparations of antimony, particularly to the inequality of their effects, and for the ſame reaſon. By introducing this new remedy, therefore, a kind of preparations eſſentially faulty, and relinquiſhed for good reaſons, has again been brought into uſe, without conſidering, that the diſeaſes, for which it is recommended, proceed from different cauſes, and ought not to be treated with the ſame remedies; as Mr. Baron has judiciouſly remarked in his edition of Lemery's Chemiſtry.

CCCXLV. GLASS *of* BORAX. Borax is, as we have ſaid under that article, a neutral ſalt, which when expoſed to fire, loſes the water of its cryſtallization; and by a ſtronger heat is further fuſible into a matter which may be drawn out, while hot, into wire, like ordinary glaſs; and which when cold, has the appearance of a very white, tranſparent glaſs. Borax thus perfectly fuſed has been called a glaſs, from its reſemblance to vitrified matters. This glaſs of borax differs nevertheleſs from true glaſs by the ſaline properties which it retains; it being entirely ſoluble in water, and again cryſtallizable into its original form of borax. It is ſuſceptible of the ſame decompoſitions as borax; in a word, it does not differ eſſentially from borax, but only in being more dry, or deprived of water.

To obtain very beautiful glaſs of borax, it ought to be guarded againſt aſhes and coals, which is conveniently done by melting it in a muffle. As this matter is very fuſible, and at the ſame time capable of facilitating much the fuſion and vitrification of ſand, and other earthy matters, it is advantageouſly uſed in the eſſays of ores, and as an ingredient in compoſitions for glaſſes and artificial cryſtals. But for this latter purpoſe a very ſmall proportion only ought to be uſed, as it imparts to glaſs the ſame property it has itſelf, of loſing its luſtre by expoſure to air. Glaſs of borax is preferred to borax for theſe purpoſes; becauſe it is deprived of all ſuperfluous moiſture, and is not ſubject to ſwell, as the borax is. *See* BORAX.

CCCXLVI. GLASS *of* LEAD. Lead is a metal eaſily calcinable; but it has a ſingular property, that when it has loſt ſo much of its phlogiſton that it cannot be reduced into metal without addition, it then retains the remaining part of its phlogiſton more ſtrongly than any other metallic matter. Hence ceruſs or white lead, minium, litharge, and all the other preparations and calxes of lead, retain always great fuſibility, and are much diſpoſed to vitrification. All theſe matters, by a moderate fire only, are eaſily fuſed, and formed into a tranſparent glaſs of a deep yellow color. But this glaſs is ſo penetrating and ſo powerful a flux, that it paſſes through crucibles as ſoon as it melts; and when it has been kept long enough in the fire to be perfectly fuſed and vitrified, none of it is to be found in the crucible, which is then glazed over internally and externally.

This property of glaſs of lead proceeds from its powerful action upon all earthy matters, by which it diſpoſes them to vitrify. Hence the difficulty of obtaining a pure glaſs of lead. A greater conſiſtence muſt be given to it, and its activity muſt be repreſſed, by uniting it with ſand, in the following manner, to render it fit for uſe.

Take two parts of a calx of lead, minium for inſtance, and one part of ſand or powdered flints. Put this mixture into a good crucible made of refractory clay, baked into a very compact body. Place this crucible in a melting furnace, after having cloſed it well with a luted lid. This crucible is to be heated by degrees, and very ſlowly; not only to prevent the breaking of the crucible, to which this kind of crucible is very ſubject, when heated too quickly, but to hinder the matter from ſwelling too much, and flowing over the crucible in the beginning of the fuſion. During an hour or an hour and a half, the fire muſt be thus managed in the beginning of the operation, and afterwards it may be encreaſed, to obtain a compleat fuſion, and continued in that ſtate during an hour or an hour and a half; after which the crucible is left to cool in the furnace; and when it is broken, a very tranſparent yellow colored glaſs is found in it. Some chemiſts direct the addition of ſome nitre and common ſalt to the above mixture, as theſe ſalts promote the fuſion, and the more equal diſtribution of the ſand.

This glaſs, which, as we have ſeen, is not a pure glaſs of lead, but in which the lead is the prevailing ingredient, has a conſiderable ſpecific gravity, and its lower part is always the heavieſt. As it is very fuſible, and eaſily re-melted with a moderate fire, and as it is beſides a very powerful flux, it is advantageouſly employed in eſſays of ores to facilitate their ſcorification. *See* LEAD *and* VITRIFICATION.

CCCXLVII. GLASS-GALL. This is a ſaline matter which riſes as a ſcum in the pots or crucibles in which glaſs is made.

This matter is chiefly compoſed of Glauber's ſalt, common ſalt, vitriolated tartar, or other neutral ſalts which cannot enter into vitrification, and which were originally contained in the aſhes or alkalis employed in the compoſition for glaſs. Glaſs-gall is uſed to facilitate the fuſion of certain ores, and in eſſays; but this matter muſt vary much, according to the kinds of alkalis or aſhes from which it is produced. (*i*)

(*i*) *Glaſs-gall*, called alſo *Sandiver*, is ſaid to contain the vitriolic acid, although no vitriolic ſalt was employed in the compoſition for the glaſs. The vitriolated tartar which is in all pot-aſh and wood-aſhes employed in the manufacture of glaſs, might account for the exiſtence of vitriolic acid in common glaſs-gall; but Pott affirms, that by melting together fixed alkali, flints, and common ſalt, a ſalt of Glauber may be produced, which he thinks very ſimilar to glaſs-gall in many of its properties; but from which, however, it differs in this, that it deliquiates by expoſure to air, whereas the ſalt of Glauber falls into a dry powder. Tachenius ſuppoſes that the vitriolic acid of glaſs-gall proceeds from the flints. Its cryſtals reſemble, as Mr. Pott ſays, partly vitriolated tartar, and partly the ſalts of mineral water. It differs from vitriolated tartar in being more fuſible, more ſoluble in water, and in being even deliqueſcent. It is uſed as a flux in eſſays of ores, and in the fuſion of filings of gold or ſilver, in the ſame manner as borax is. It is even ſaid to increaſe the malleability of metals. *See Pott's Diſſertation on Glaſs-gall.*

CCCXLVIII. GOLD. Gold, called alſo by chemiſts the *Sun*, *Sol*, and the *king of metals*, is a perfect metal, of a yellow ſplendid color, and unalterable by all the operations of art. This is the moſt perfect of all metals; its principles are the beſt combined, and it poſſeſſes moſt eminently the metallic characteriſtics.

When gold is very pure, it has no taſte nor ſmell, even when heated and rubbed. It loſes in water betwixt $\frac{1}{19}$ and $\frac{1}{20}$ part of its weight. A cubic foot of gold weighs 1326 pounds. It is the heavieſt of all metals, and conſequently of all known bodies.

The hardneſs of gold is intermediate betwixt that of the hard and of the ſoft metals. Its ductility is ſurprizingly great, and exceeds that of all metals. From calculations made by experimental philoſophers concerning the extenſion of gold upon ſilver, a ſingle ounce of gold, the bulk of which is very ſmall on account of its great weight, is found to be capable of covering and gilding perfectly a ſilver wire 444 leagues in length.

The gold-beater's art, by which gold is formed into ſuch thin leaves that they are made to float in the air by a light breath, is a further proof of its great ductility, and is alſo a proof of its extreme opacity: for theſe gold leaves are ſtill perfectly opake. Light may indeed be perceived through them; but this is owing to cracks, which may be eaſily perceived upon examining the leaves, and which are occaſioned by the repeated ſtrokes of the hammer.

When gold is ſtruck during a certain time by a hammer, or when violently compreſſed, as it is by gold-wire-drawers, it becomes more hard, elaſtic, and ſtiff, and leſs ductile, ſo that it is apt to be crackt and torn. The ſame thing alſo happens to the other metals by percuſſion and compreſſion. Ductility and tractability may be reſtored to metals in that ſtate, by making them red-hot, which is called *annealing* them. Gold ſeems to be more affected by percuſſion and by annealing than other metals.

The tenacity of the parts of gold is alſo much greater than of any other metal. For 500 pounds can be ſupported by a wire of $\frac{1}{10}$ of an inch in diameter made of gold, but not of any other metal.

Gold is unalterable by air and by water. It never contracts any ruſt; and when its ſurface loſes its luſtre, this is occaſioned by the adheſion of extraneous matters, and not by any deſtruction of the metal. The action of fire does not occaſion any alteration upon gold. When expoſed to fire it ſoon becomes red, and when it has acquired a vivid redneſs, like that of a burning coal, it ſoon melts. Its ſurface has then a light green color, like that of a beryl. No vapor or ſmoke riſes from gold during its fuſion; and it ſuffers no loſs of weight by that operation, however long continued, or with the moſt violent fire. Kunckel kept gold in a glaſs-houſe furnace during a month, and Boyle kept ſome ſtill longer expoſed to great heat, without the loſs of a ſingle grain or any alteration.

Gold reſiſts alſo, while its aggregation is entire, the action of the ſtrongeſt ſimple chemical menſtruums, either in the dry or in the humid way. It is not ſoluble either by the ſtrongeſt mineral acids when they are pure, nor by ſulphur, nor by alkalis. Two compound bodies, nevertheleſs, are powerful ſolvents of gold. The firſt is a mixture of the nitrous and marine acids, called by chemiſts

chemists *aqua regia*, because it dissolves gold, the king of metals; and the second solvent of gold is a combination of sulphur with fixed alkali, called *liver of sulphur*.

The solution of gold in aqua regia is very easy. A very small quantity of nitrous acid, or even of inflammable matter, mixed with marine acid, gives this latter acid the property of attacking gold. Also a very small quantity of marine acid, or of any of the salts containing it, mixed with nitrous acid, renders this nitrous acid capable of dissolving a certain quantity of gold. But experience has shown, that an aqua regia composed of four parts of nitrous acid, and one of sal ammoniac, dissolves perfectly well a fourth or a third part of its weight of gold, according to the strength of the acid. *See* AQUA REGIA.

To make this solution, the gold is to be reduced into filings or thin plates, and put into a small matrass. Upon this gold the aqua regia is to be poured, and the matrass is to be placed in a sand-bath moderately heated. As soon as the aqua regia is sufficiently heated, it attacks the gold with all the usual phenomena which accompany solutions of metals in acids. But in this solution the effervescence is only moderate. While the aqua regia dissolves the gold, it acquires a beautiful yellow color, which becomes more and more intense, till it has a golden, or even an orange color. When the menstruum is entirely saturated with gold, the solution is very clear and transparent.

The power which the nitrous and marine acids acquire by their union, of dissolving gold, which neither of them have separately, is one of the most remarkable facts in chemistry, and favours much the opinion which admits the three earths or principles of Becker as the constituent parts of metals, because that fact is well explained by this doctrine. If marine acid contains the mercurial principle, as nitrous acid contains the inflammable principle; and if, on the other side, both these principles constitute metals, by their union with the earthy principle; we may easily conceive that all those metallic matters, in which the union of these principles is weak and imperfect, may be attacked indiscriminately by the nitrous and marine acids separately: because when any of these acids finds in the metallic matter the principle which is analogous to it, weakly combined, it may be capable of attacking that metallic matter, by means of this analogous principle. But if these principles be strongly united together, as many reasons concur to prove they are in gold, since it is the most perfect and indestructible of metals; then we may easily conceive that while these acids act on the gold separately, the mercurial principle may be defended from the action of the marine acid by the inflammable principle, and reciprocally the inflammable principle may be defended from the action of the nitrous acid by the mercurial principle; and that thus gold cannot be dissolved by either of these two acids separately.

But we may at the same time easily perceive, that if two acids united make a combined attack upon gold, that is, if the marine acid attacks the mercurial principle of the metal, while the nitrous acid attacks the inflammable principle, the action of this compound menstruum will be twice as strong as that of any of the two acids separately, and they may therefore perform the solution conjointly, which neither of them could do singly.

Gold receives no alteration in its composition from the acids of aqua regia. This solution is corrosive, as also all other metallic solutions are. It gives a violet color to the fingers, or to any animal matters, for the same reason that solutions of silver and mercury in nitrous acid tinge these matters black. If the solution be evaporated and cooled, yellow transparent crystals like small topazes will be formed. But if the evaporation be carried too far, the acids with which the gold is united may be driven from it by heat alone, and the gold will be left in the state of a yellow powder, called *calx of gold*.

Gold may be precipitated from its solution by those intermediate substances which generally precipitate metals from acids; that is, by alkalis fixed and volatile, by calcareous earths, and by some other metals. But volatile alkali seems to precipitate gold more easily than fixed alkalis; at least gold is very slowly precipitated from an aqua regia made without sal ammoniac by fixed alkali, but is copiously and instantly precipitated by volatile alkali. Fixed alkali also precipitates it copiously and speedily from aqua regia made with sal ammoniac; but in this case the volatile alkali in the nitrous ammoniacal salt, contained in this aqua regia, is evidently disengaged by the fixed alkali, and contributes to the precipitation.

All these precipitates of gold, although yellow, have not a metallic brilliancy, because they retain part of the dissolving and precipitating salts. In other respects, they, and also the calx of gold above-mentioned, are nothing but gold unaltered; and when melted without addition, become entirely like the metal before it was dissolved.

Gold precipitated by a volatile alkali from its solution in aqua regia has an astonishing property, namely, its power of exploding with violence and terrible noise, when heated to a certain degree. It is accordingly called *fulminating gold*. *See* GOLD (FULMINATING). This property has not been observed in any other metal.

Although a mass of gold, that is, gold, the aggregation of which is entire, resists the action of simple solvents, as we have seen, we must not conclude that it is absolutely incapable of solution by any of these simple solvents. On the contrary, Mr. Margraaff has discovered, that this metal, precipitated by an alkali from its solution in aqua regia, is then rendered soluble by any, even the vegetable, acids. Besides, gold dissolved in aqua regia is not precipitated, when the proportions of the two acids of this compound menstruum are changed, by adding to this solution any quantity of nitrous or of marine acids. Lastly, gold may be dissolved in alkalis by the process of the martial alkaline tincture of Stahl; that is, by pouring into a concentrated solution of fixed alkali in water, a small quantity of solution of gold in aqua regia in which the acids are not too much saturated, the gold will be quickly seized and dissolved by the alkali.

All these experiments prove, that the just proportion and intimate connection of the principles of the gold are not the only causes which render it insoluble, or difficultly soluble by menstrua which easily attack the other metals, but that its great density and strength of its aggregation contribute also much to this effect; since, when this aggregation is broken by a previous solution in aqua regia, it easily yields to the action of other solvents.

Melt

Most metals are capable of separating gold from aqua regia by precipitation. The precipitate occasioned by adding tin is the most remarkable of these. It has not the metallic splendor, as metals precipitated by other metals generally have; but it is of a beautiful purple color, when well made. This precipitate, called *Cassius's precipitate of gold*, is used to give a crimson color to vitrified matters. *See* PRECIPITATE *of* GOLD (CASSIUS'S).

Oily, thin, ethereal substances have great affinity with gold. If a light, essential oil, and still better if ether, be poured upon a solution of gold in aqua regia, and the mixture be shook, the gold will be seen to pass into the oily matter, which will float upon the aqua regia now deprived of its metal. This is one of the best methods of making potable gold. *See* GOLD (POTABLE).

Neither sulphur nor fixed alkali can act separately upon gold. But the liver of sulphur, which is composed of these two substances, is also a great solvent of this metal. This solution can be well made only by the dry way. To make it succeed, gold-leaves are to be mixed with liver of sulphur, put into a crucible together, and very quickly fused. The gold will be attacked by the liver of sulphur, and will very soon disappear. If this liver of sulphur thus impregnated with gold be dissolved in water, the metal remains suspended, and may be even passed through a paper filter.

This is also a method of making potable gold, the taste of which is very disagreeable, from the liver of sulphur. Stahl has written a dissertation concerning this method of dissolving gold, by which, he thinks, Moses might have dissolved and rendered potable the golden calf mentioned in scripture (*k*). As the liver of sulphur is decomposed by time, and changes into vitriolated tartar by exposure to the air, the gold therefore must also separate from it.

When a solution of gold in liver of sulphur is precipitated by an acid, the sulphur and gold are precipitated together; and in this case the precipitate is not white, as it is from a pure liver of sulphur, but acquires a yellow color from the gold. The gold and sulphur thus precipitated together are not united, but are easily separable by fire, which consumes the sulphur, and leaves the metal pure.

Gold may be allayed with all metals; but these allays are not much used, excepting with silver and copper, for coins and gold plate; with mercury, in the extraction of gold from the ore or matrix containing it, and for gilding; with lead and with regulus of antimony, for its purification by these substances.

Gold allayed with any metallic substance is always less ductile than when pure; which observation is applicable in general to all allays. *See* ALLAY.

The color of gold is considerably altered and rendered paler by silver, and is, on the contrary, much exalted and heightened by a mixture of copper. Cop-

(*k*) Moses was probably a good chemist, as he had been instructed in all the wisdom of the Egyptians, and possibly might have known the solubility of gold by liver of sulphur; but those persons who cannot be convinced that he was assisted by divine power, in this and all other instances of his administration, will scarcely believe that he could persuade the Israelites to swallow so fetid, and perhaps so poisonous a potation, as a solution of gold by liver of sulphur; or that he knew no better method of employing this precious calf, than by applying it as an emetic to his countrymen.

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per alſo diminiſhes very little the ductility of gold, and gives it more firmneſs and ſolidity. Accordingly the allay of copper with gold is much uſed.

Gold cannot be ſeparated from ſilver but by expoſing this allay to the action of menſtruums, which can only diſſolve one or the other of theſe two metals, that is, acids and ſulphur. *See* PARTING.

All other metals may be ſeparated from gold by ſcorification with lead, by nitre, and by antimony, or rather by the ſulphur of the antimony. *See the details of all theſe operations, under the words* REFINING, CUPELLATION, PURIFICATION *of* GOLD, *and* SMELTING *of* ORES.

All that we have ſaid concerning the properties of gold ought to make us conſider it as a metal, indeſtructible, fixed, and not to be decompounded. But this does not prove that it is a ſimple body, and abſolutely unalterable. On the contrary, we have reaſon to believe that its reſiſtance to all our operations is owing to our inability to raiſe a ſufficient heat; and that if it were expoſed to a fire infinitely ſtronger, ſuppoſe near the ſun, or even within the ſun, it would be burnt and decompoſed, as the imperfect metals are, in a moderate fire, and perhaps would be reduced into vapors.

Some chemiſts pretend that they have been able to calcine gold. Homberg ſays, in the Memoirs of the Academy of Sciences, that having expoſed gold to the focus of Tſchirnhauſen's great lens, he ſaw this metal ſmoke, and become a glaſs. But according to the tradition preſerved in the Academy, this experiment is not ſufficiently authenticated, and is one of thoſe which require to be repeated with great care. (*l*)

Kunckel ſays, that he changed gold into an irreducible calx, by long calcination, without fuſion, and by reverberation in the manner of Iſaacus Hollandus. This experiment alſo is not very well aſcertained, becauſe no chemiſt has had patience enough to repeat it.

Laſtly, the true alchemiſts do not make any doubt of the poſſibility of decompoſing, or entirely deſtroying gold. Their books are filled with proceſſes by which they affirm, that this metal may be radically diſſolved; its principles ſeparated; its ſulphur, as they call it, its tincture, and its ſoul, may all be extracted.

In Junker's Chemiſtry we find, that Langelot, and Borrichius in his Treatiſe concerning the Wiſdom of Hermes and of the Egyptians, ſay, that if gold leaves be triturated upon a porphyry during fourteen days and nights, the gold will at laſt be changed into a black powder, which contains ſomething viſcous, volatile, of a ſulphureous ſmell, and which being diſtilled with a graduated heat in a ſhallow retort, furniſhes ſome drops of a very red liquor.

This experiment is evidently very long, laborious, and liable to error, as moſt of this kind are. For it is almoſt impoſſible, but that during ſo long a

(*l*) Homberg ſays, that part of the gold was vitrified, and ſuppoſes only that the reſt might alſo have been vitrified. But he did not aſcertain the purity of the gold which he employed, and therefore the glaſs produced in this experiment might proceed from copper, or other metal with which the gold might have been allayed, or from the aſhes of the charcoal which ſupported it; which we find was the opinion of ſome perſons who had been preſent at that experiment.

trituration, a sensible quantity of heterogeneous matters should be mixed with the gold, if it were only those which are continually floating in the air. *(m)*

Borrichius says also in the same work, that a plate of gold, being made red-hot and extinguished in water many times, gives an astringent taste to the water, which seems to shew a kind of solution of gold by water. But was the gold, and also the water employed by Borrichius in this experiment, perfectly pure? We know with what difficulty gold can be obtained perfectly pure, and that no water but distilled water is fit for chemical experiments.

Becker, in his second Supplement to the *Physica Subterranea*, gives a process to render gold as soft as lead, and to encrease its fusibility. This process consists in throwing melted gold a number of times into a liquor composed of spirit of sal ammoniac and rectified spirit of wine. I do not believe that this experiment has been repeated by any chemist. If it succeeds, the softness and fusibility which the gold acquires may probably be caused by a superabundance of inflammable principle communicated to it by these two liquors.

The author of a treatise called *Alchymia Denudata* affirms, that if half an ounce of gold be melted with two ounces of copper, and the copper be afterwards separated from the gold with eight times as much aqua fortis not depurated, and if this work be repeated nine times, the gold will receive so lively a red color, that it would scarcely be known to be gold, and so fixed as to sustain all the ordinary trials without hurt or loss. This experiment deserves to be repeated. We do not see why the author directs the use of undepurated aqua fortis, or of such as probably contains some marine acid. Such an aqua fortis seems, on the contrary, very unfavorable to the experiment; for as it is a little of the nature of aqua regia, it may dissolve some of the gold.

Roth advances in his Chemistry, that gold may be dissolved in spirit of nitre distilled in Glauber's manner, the vapors of which have been received and condensed by highly rectified spirit of wine. In this experiment, nitrous ether must be formed, and we know that ether has a strong disposition to unite with gold: therefore this solution ought to succeed better, as the ether is here assisted by the action of the nitrous acid. But this solution of gold probably does not differ much from the ordinary tincture of gold made with nitrous ether. *See* Gold (Potable).

Kunckel, in his Chemical Laboratory, proposes as an excellent solvent of gold, but which acts exceeding slowly, the subtle vapor which arises during the re-action of deliquiated fixed alkali with vitriolic acid. This vapor seems indeed to be very subtle and active, by the impressions it makes upon our organs of smelling; but these qualities are only apparent, and we cannot easily be-

(m) Junker also relates from Borrichius and Olaus..der, that by a long trituration of an amalgam of gold with distilled water, a black powder was formed, which was convertible into green glass, and that the water became impregnated with a saline matter; and that by this method the gold may be destroyed. Dr. Lewis observes, that the green glass probably proceeded from abraded parts of a glass mortar, that the saline matter had probably pre-existed in the water or was extracted from the glass, and that the black powder was produced by the trituration of the mercury. The same author says, that he has triturated an amalgam of gold during a week, without destroying any part of the gold.

lieve that this vapor is capable of dissolving gold, excepting the vitriolic acid be impure and sulphureous. I collected a considerable quantity of this vapor by saturating fixed alkali with vitriolic acid in a tubulated glass alembic. The vapor when condensed into a liquor seemed to be nothing but pure water. Its poignant smell, therefore, seems to be nothing but the air which is disengaged in all these effervescencies, and which by interposing itself betwixt the parts of the water, gives this spirituous quality to the water, which Mr. Venel has shewn to exist also in the mineral, aerial, and spirituous waters. *See* WATERS (MINERAL).

Cassius, in his Treatise *de Auro*, mentions a process to obtain very red crystals of gold of a violet smell. For this purpose he directs gold leaves to be dissolved by help of a long continued heat, in a liquor composed of a pound of the phlegm of ordinary aqua fortis, and of four ounces of common salt. When the solution is made, the crystals above-mentioned may be obtained by crystallization, in the ordinary method. As this is merely a solution of gold in aqua regia, the peculiar color and smell of the crystals probably proceed from matters extraneous to this metal. Besides, marine acid when weakly attached to a basis without smell, always emits an odor similar to that of violets.

Glauber, in his Treatise *de Lapide Animali*, gives a process for dissolving gold, by which also it is remarkably altered. This process consists in dissolving two or three ounces of hartshorn in an aqua regia made by distilling together nitre and decrepitated common salt (by means undoubtedly of some substance capable of disengaging the acids). Then a dram of gold leaf is to be put into this liquor, which is to be afterwards distilled off from the gold in a glass cucurbit, during which distillation the gold is dissolved; and when the liquor is drawn off, at the bottom of the vessel, a mass will be found composed of all the ingredients employed. This mass is then to be fused very quickly in a forge fire, and in an open crucible; by which it is changed into a black scoria, under which the gold is found rendered white and brittle like regulus of antimony. If this experiment be true, we cannot easily conceive why the gold should acquire this whiteness and brittleness, except we impute it to the mercurial principle of the marine acid; which acid, being retained by the union it forms with the earth of the hartshorn, may be supposed capable of a partial decomposition by the gold and by the fire; and thus a portion of the mercurial principle, which many chemists believe to be one of the constituent parts of the marine acid, might apply itself to the gold, and unite with it superabundantly. Such an experiment well confirmed, would certainly indicate the presence of the mercurial principle in the marine acid.

As most chemists have made wonderful experiments on gold, their books are filled with many other processes of this nature, by which very curious and interesting phenomena result, and which therefore deserve to be repeated. But as they are at the same time almost always obscure, confused, and full of tedious and embarrassing operations, they require a very careful examination. Those processes which we have described as examples of this kind were chosen as the most practicable, and which give the most hopes of success.

Mr. Limburg, who has written a Dissertation, which obtained the prize from the academy at Rouen, concerning chemical affinities, gives a table of affinities,

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in which he establishes those of gold in the following manner; aqua regia, liver of sulphur, mercury, ether, silver, iron, and lead.

The principal uses of gold are well known. It is very proper to be formed into coin, and into various ornaments, from its lustre, beauty, and undestructible quality. By means of the art of gilding, much external beauty, neatness, and richness is given to many utensils and toys. A fine color also is obtained from gold for enamel and porcelain painting. Many persons have been of opinion, and many still are, that a remedy superior to all others may be extracted from gold, capable of procuring long life. The truth of this opinion is more than doubtful. *See* GOLD (POTABLE). With gold, an explosive powder more terrible and destructive than gun-powder may be made. This powder is called fulminating gold. *See* GOLD (FULMINATING). (*n*)

CCCXLIX. GOLD (FULMINATING). This preparation is gold precipitated from its solution in aqua regia. It is called fulminating, because, when it is heated or rubbed so as to acquire a certain heat, it makes an explosion similar and perhaps superior to that of thunder.

The method always used to prepare fulminating gold, consists in dissolving this metal in a sufficient quantity of aqua regia, which is generally made with spirit of nitre and sal ammoniac; from which the gold is to be afterwards precipitated by adding fixed alkali. A copious precipitate of a yellow and somewhat reddish color is soon formed. This precipitate washed and dryed is fulminating gold.

The phenomenon of fulmination is certainly one of the most striking and wonderful which chemistry affords. The cause of this fulmination is not easily to be discovered. But the following facts may suggest hints to explain it.

(*n*) For further particulars concerning gold, *see the articles* ESSAY *of the* VALUE *of* GOLD; PURIFICATION *of* GOLD *by* ANTIMONY; PARTING; ORES *of* GOLD; GILDING; *and* ALLAY. Every thing almost that is known concerning gold, its natural history, its chemical properties, and its use in arts, are treated copiously and accurately by Dr. Lewis, in his very useful work, intitled, *Philosophical Commerce of Arts*.

We shall here make some additions to the metallurgic history of gold. 1. The color of gold is rendered paler by fusion with borax; which substance, or other flux, is used to facilitate the fusion of filings of gold. The paleness acquired by gold from borax may be prevented or corrected by fusion with nitre, or with sal ammoniac. 2. The color of gold is heightened by an allay of copper, which also encreases its hardness, and when in small quantity, as in the proportion of one to twelve, does not much diminish its malleability. Other metals render it paler. *See* ALLAY. See also the methods of heightening the color of gilding at the article GILDING. 3. The malleability of gold is diminished by cooling it, when fused too hastily.* To prevent which, artists heat the mould into which the gold is to be cast. 4. The malleability of gold is destroyed by fumes of lead and of most other metallic substances; and may be recovered by fusion with nitre. Many authors say that the malleability of gold is injured by the fumes of charcoal, but Dr. Lewis believes this to be a mistake. 5. Gold may be melted with a low white heat, and when melted has a bright blueish green color. Dr. Lewis observes, that although its expansion is less than that of other metallic substances with small degrees of heat, it nevertheless expands more than most of the other metals when fused; and that this property, by which it shrinks more when it becomes solid than most other metals, renders it less capable of receiving sharp and perfect figures, when cast into moulds, than silver, copper, lead, and tin, which do not shrink so much, and far less so than iron or bismuth, which expand in their passage from a fluid to a solid state.

First,

First, if gold be diffolved in an aqua regia compofed of nitrous acid, and of marine acid or common falt, and to which no fal ammoniac is added; and if this gold be precipitated by fixed alkali, this precipitate does not fulminate. On the contrary, it fulminates ftrongly, if it be precipitated from this fame aqua regia by a volatile alkali. Thefe facts were well known to chemifts. One of the menftruums employed by them to diffolve gold, is the liquor which they call *menftruum fine ftrepitu*; this folvent is a compound of equal parts of alum, nitre, and common falt, with which the gold is firft to be ground; water is then to be added, and the whole digefted, that the falts may act upon the gold. By this method the gold is found to be entirely diffolved. In this operation the vitriolic acid of the alum difengages the acids of the nitre and of the common falt, and thus an aqua regia is formed, in which no fal ammoniac, and confequently no volatile alkali, enters. Hoffman and Etmuller affirm, that if gold be precipitated by a fixed alkali from its folution in this menftruum fine ftrepitu, this precipitate of gold does not fulminate, but that it fulminates ftrongly when the precipitate is made by volatile alkali.

Secondly, when gold is diffolved in an aqua regia in which fal ammoniac enters, its precipitate, whether by a fixed or by a volatile alkali, always fulminates.

Thirdly, when fulminating gold is prepared, and all the precipitate carefully collected, we find that its weight fenfibly exceeds that of the gold employed; that is, a fourth more of fulminating gold is obtained, than the gold which was diffolved.

Fourthly, fulphur, or vitriolic acid, or fixed alkalis, being well mixed with fulminating powder, deprive it of its fulminating quality.

The firft and fecond of thefe experiments prove clearly, that in order to procure fulminating powder, a nitrous ammoniacal falt muft be formed in the operation. The augmentation of the weight of the gold fhews alfo that this ammoniacal nitrous falt applies itfelf to the gold during the precipitation, and incorporates with it.

Laftly, the methods, by which the fulminating property of this precipitate may be deftroyed, are alfo capable of decompofing the nitrous ammoniacal falt. The acid of fulphur, or vitriolic acid, feparates its nitrous acid, and forms a vitriolic ammoniacal falt, by uniting with its volatile alkali; and the fixed alkali difengages its volatile alkali, and forms ordinary nitre with its nitrous acid.

All thefe facts feem to prove, that the fulminating property of the gold is occafioned by the nitrous ammoniacal falt formed during the precipitation, and which very ftrongly and intimately unites with the metal. Further, this nitrous ammoniacal falt is known to be fufceptible of detonation when heated to a certain degree, and without addition of any combuftible matter, which property is occafioned by the quantity of inflammable matter which its volatile alkali contains. This detonation of nitrous ammoniacal falt is indeed very fmall, when compared with that of fulminating gold. But all explofive bodies are known to produce explofions fo much the ftronger as they are more confined and compreffed. But the parts of the ammoniacal falt may be fo combined with the gold as to be ftrongly included within the particles of the metal.

If the explosion of the fulminating gold only proceeds from the detonation of the nitrous ammoniacal salt which it contains, as we have reason to believe, it must certainly be the effect of the inflammation of the nitrous sulphur, in which chiefly consists the detonation of nitre. *See* Detonation *of* Nitre.

Mr. Beaumé has a particular opinion on this subject. He thinks that the nitrous sulphur which occasions the fulmination of gold, is formed during the precipitation, by the union of phlogiston with nitrous acid; that this nitrous sulphur exists mixed with the gold, and ready formed before its fulmination; and consequently that the nitrous ammoniacal salt does not contribute to the production of this effect.

The chief proof which he brings to support this opinion, is, that if fixed alkali be poured upon fulminating gold, no smell of volatile alkali arises. Mr. Beaumé further affirms, that fulminating gold may be boiled in any quantity of water, provided that water be pure, that is, distilled, without loss of its fulminating quality; which experiment seems to shew, that the fulminating quality is not occasioned by any saline substance soluble in water, as the nitrous ammoniacal salt, but rather by some substance insoluble in water, as the nitrous sulphur probably is, from its analogy to vitriolic sulphur. This is certainly an ingenious thought, and we wish that Mr. Beaumé would prosecute, prove, and explain it fully, as it deserves. *See* Sulphur (Nitrous).

But whatever be the cause of the fulmination of gold, we are certain that the explosion occasioned by it is one of the most violent which are known in chemistry. It is not necessary that fulminating gold should be touched by an ignited matter, or that it should be heated till it becomes red, to make it explode. The heat requisite for this purpose is intermediate, betwixt that of boiling water and the heat which makes metals of an obscure red color. Friction alone, and even a friction not very considerable, is sufficient to make it fulminate; and this effect is produced either in open or in close vessels. These circumstances render fulminating gold very dangerous. Several chemists, from not sufficiently knowing its effects, have been hurt or killed, while they were pounding and drying it. I was witness to the following accident. A young man, who worked in a laboratory, had put a dram of fulminating powder into a glass bottle, and had neglected to wipe the inner surface of the neck of the bottle, to which some of the powder adhered. When he endeavored to close this bottle, the turning the glass stopper round, to make it fit more closely, occasioned such a friction, that heat enough was produced to make part of the powder explode. By this explosion the young man was thrown some steps behind, his face and hands were wounded by the fragments of the bottle, and his eyes were put out. Notwithstanding the violence of this explosion, the whole dram of fulminating gold did certainly not explode. Probably even very little of it was exploded, for much of it was afterwards found scattered about in the laboratory, in its unexploded state.

A misfortune of this kind is so terrible, and at the same time so difficult to be prevented by those who are not sufficiently initiated in chemistry, that I thought a relation of this accident ought to be published.

The gold is not altered by this sudden and violent inflammation. Of this we may be assured by detonating so small a quantity of fulminating gold under a glass bell, that nothing is to be feared from the explosion. The gold may

be

be afterwards observed to adhere, in its proper metallic state, to the inner surface of this bell. (*o*).

CCCL. GOLD (POTABLE). Alchemists have always believed that gold possesses admirable virtues for the cure of many diseases, and for the prolongation of life. They have consequently laboured much to procure remedies from this metal, and they have accordingly invented many preparations, any one of which, if we believe the inventor, is capable of curing all evils. But the constant observation of the most intelligent practitioners not having confirmed these pretended qualities, this metal is not employed by physicians. Many ignorant people have still the prejudice of its great virtues; and empyrics, who know how to profit by the weakness of men, keep up and strengthen this prejudice, by continually boasting of their elixirs and tinctures of gold, and of their potable gold, which they always declare to be wonderful secrets.

The indestructible quality of gold sufficiently shews, that no effect can be produced upon it in our body, for we are certain that it is voided unaltered; and it is only used in pharmacy to cover and conceal other remedies, or to give them an air of wealth and grandeur which pleases some people.

This inactivity of gold in its natural state, seems to be acknowledged by the most ignorant, for all the quacks who boast of their golden remedies declare that they can radically dissolve it. But this pretension is as useless to an intelligent physician as it is ill-founded, since the example of many other metallic matters, the virtues of which are ascertained, although they are not dissolved radically, proves that such a solution of gold, supposing even that this metal had virtues, would be very unnecessary. Accordingly when we examine the preparations given for potable gold, we find that a part of them contains no gold, and the gold which others do actually contain may be easily extracted, and reduced to its natural state.

(*o*) The expansion of fulminating powder seems to be more sudden and quick, but less forcible than that of an equal quantity of gunpowder. The quickness of the expansion of fulminating gold, is inferred from the loudness of its explosion, which is much greater than that of gunpowder; and from its perforating or impressing a metalline plate, upon which it is laid unconfined, and is exploded; which effect is not produced by gunpowder; the cause of which seems to be, that the force of the explosion of gunpowder is applied so slowly and gradually, that it may be communicated from the part of the plate which the powder touches to the other parts of the plate, and thus the force is resisted by the vis inertiæ of the whole plate; whereas in the explosion of fulminating gold, the whole force is so suddenly applied to the contiguous part of the plate, that it is capable of perforating or impressing that part before it can be communicated to the rest of the plate. Now, though the force applied during the instant of the explosion of fulminating gold, be greater than the force of exploding gunpowder during that instant, yet the sum of the forces of exploding gunpowder, in the several instants of its explosion, is probably much greater than the whole force of fulminating gold, because a quantity of aurum fulminans shut up in a strong hollow iron ball, and heated in the fire, did not seem to explode; while gunpowder treated in the same manner burst the ball. This experiment is related in *Dr. Birch's History of the Royal Society*, vol. I.

Dr. Black attributes the encrease of weight, and also the explosive property of fulminating gold, to adhering fixable air. *See his essay on quicklime*, amongst the *Essays physical and literary*, published at Edinburgh, vol. II.

To render gold potable, it must be previously dissolved. This may be done in aqua regia, or even in any of the acids, with proper management; but by this method gold and the other metals are rendered corrosive. This is so well known, that the preparers of potable gold affirm that their solutions are made without any acid. But as all the very thin and volatile oily substances have a strong disposition to unite with gold, and do really unite with it when they find it much divided, by their means may be made several tinctures of gold, or kinds of potable gold. If these preparations do not acquire any virtue from the gold which they contain, they have at least that of the inflammable subtile matter, which is the vehicle of the gold. *See* OILS (ESSENTIAL) *and* ETHER.

Subtle essential oils, ethereal liquors such as the vitriolic and other ethers, being mixed and agitated with a solution of gold in aqua regia have a property of depriving this aqua regia of its gold, which it seizes, so as to carry it to the surface of the liquor, where it floats upon the aqua regia. Many receipts for potable gold are upon these principles. One of these is in the Dispensatory of the Faculty of Medicine in Paris. It consists in mixing and agitating sixteen parts of essential oil of rosemary with one part of gold dissolved in aqua regia, in separating afterwards this aqua regia thus deprived of gold from the essential oil which contains it, and in dissolving this essential oil in five times its weight of rectified spirit of wine. This preparation is the same as that described in the last edition of Lemery's Chemistry, under the name of *potable gold of Mademoiselle Grimaldi*. As all essential oils have the same property of taking gold from the aqua regia, potable gold may be made with any of these, as well as with the oil of rosemary.

As ether possesses eminently all the properties of the most attenuated and volatile oils, it produces the same effect, and better than essential oils, upon the solution of gold; so that potable gold may be made by any of the ethers in the same manner as by the essential oils. Mr. Pott having perceived a smell of ether in a potable gold, sold under the name of *Drops of General de la Motte*, imagined that this preparation was made with ether. But as these drops are miscible with water in any proportion, a quality which does not belong to pure ether, this smell of ether probably proceeds from a small quantity of nitrous ether formed by the mixture of the nitrous acid of the solution of gold with spirit of wine, both which are certainly ingredients in this preparation.

All these tinctures of gold are nothing but gold in its natural state, exceedingly divided, and suspended in an oily liquor. They are not therefore, properly speaking, tinctures. Neither can they be called potable gold in any other sense than that it swims in a fluid, and is divided into so fine parts, that it may be drank under the appearance of a liquor, as Mr. Baron well remarks in his edition of Lemery.

We ought to observe, that all these preparations we have mentioned contain a certain quantity of the acids of aqua regia; and that they are, notwithstanding, apt to deposite in time a considerable quantity of the gold they contain, unless the contained quantity be very small. Gold is deposited, particularly from the mixture of ether, in its metallic state, and is even very brilliant.

Lastly,

Lastly, as gold may be dissolved and reduced into a liquor, as well by liver of sulphur as by aqua regia, a potable gold may also be made by that solvent. Nevertheless we have not seen any potable gold made in that manner, probably from the insupportable smell and taste of the liver of sulphur.

CCCLI. G R A I N. A grain is the smallest weight used in the ordinary operations of chemistry. It is nearly equal to the weight of a grain of corn, from which it has received its name. A grain is the 24th part of a scruple, $\frac{1}{72}$ part of a gros, the $\frac{1}{576}$ part of an ounce, &c. (*p*).

CCCLII. G R A I N S. The seeds of most vegetables are so called. Two principal kinds of seeds are distinguished in chemistry, relatively to the predominant substances which are obtained from them. Some of them contain at the same time a considerable quantity of mucilage and oil, which may be separately extracted from them; the former by infusion in water, and the latter by expression, or both together by trituration with water, in form of an emulsion. These are therefore called emulsive grains or seeds. Of this kind are almonds, and the seeds of almost all fruits. The other grains are called *farinaceous*, because they contain no superabundant oil like the former, but are entirely composed of a dry substance easily reducible into a fine powder, called meal, from which water can extract a large quantity of mucilaginous, nutritive, saccharine matter, and which is very susceptible of the spirituous fermentation. Of this kind are the grains of all gramineous and leguminous plants, the fruits of which are only coverings including grains.

CCCLIII. G R A N I T E. A granite is a stone formed by the cohesion of small stones of different colors, and of different natures.

This disposition constitutes it a stone composed of small particles, called grains; and hence it is called granite.

Most granites are formed by particles of quartz, spars, sand, and mica or talk, of different colors. As quartz and sand generally predominate in granites, these stones strike fire with steel, and are classed amongst the hard stones. Nevertheless, granites differ much in this respect. Granites are found in large masses. Some of them are very beautiful, when cut and polished. Many beautiful granites are found in Brittany. The most valuable granites are brought from Egypt. (*q*).

CCCLIV. G R A N U L A T I O N. Granulation is an operation by which metallic substances are reduced into small grains or roundish particles, the use of which is, to facilitate their combination with other substances.

This operation is very simple. It consists in pouring a melted metal slowly into a vessel filled with water, which is, in the mean time, to be agitated

(*p*) The weights mentioned in the text are French. A grain is $\frac{1}{29}$th part of an English troy pennyweight, or $\frac{1}{585}$th part of a troy ounce. *See the article* WEIGHTS.

(*q*) Granites are very various in their appearance, as they are in the colors and proportions of their component particles. These particles consist of common quartz, of that species of quartz called *feltspar* or rhomboidal quartz, and of mica, with which also are often accidentally mixed particles of other stones, as of steatites, basaltes, garnets, and metallic earths. The rocky summits of the highest mountains generally consist of this compound stone, or of porphyry, which is also a compound stone, and different from granite only in containing, besides quartz, feltspar, and mica, a great deal of the opake colored siliceous stone called jasper.

with a broom. Lead is alſo granulated by pouring it when melted into a box, the internal ſurface of which is to be rubbed with powdered chalk, and by ſhaking ſtrongly the box, till the lead has become ſolid. What paſſes in theſe operations may be eaſily imagined. Metals are granulated becauſe their ductility renders them incapable of being pounded, and becauſe filing is long, tedious, and might render the metal impure by a mixture of the iron of the file. (r).

CCCLV. GRAVITY. Gravity is the property of bodies, by which they endeavor to approach each other. Thus, for example, we know that a body reſting upon the earth cannot be raiſed but by a force ſuperior to what is called its weight; and that this body thus raiſed, returns precipitately to the earth, when it is no longer ſupported Men in general have always obſerved this phenomenon without attending to it. But philoſophers have always admired it, and have endeavoured to diſcover its cauſe, but without ſucceſs; which is not ſurpriſing; for we do not yet know all the circumſtances attending gravity. We are not yet certain, that all the particles of matter have this property. The gravity of the air was not diſcovered till the laſt age. We will not therefore attempt to reaſon upon this obſcure ſubject. But as the particular effects of gravity influence much all chemical phenomena, and as the particular gravity of the integrant parts of different ſubſtances is probably the primary cauſe of the action of theſe ſubſtances upon each other, we muſt enter into ſome detail upon this ſubject.

The gravity of a body may be conſidered in two manners. Firſt, every body, conſidered as heavy, cannot be compared but to greater or leſs quantities of the ſame kind of matter. In this caſe, we may obſerve that the greater the quantity of matter of any body is, the greater is the effect of its gravity. Hen e the gravity of bodies is directly as their maſſes or quantities of matter. The ravity of bodies conſidered in this view is called their *abſolute gravity*, that

(r) The granulation of metals by agitation in a box, is thus explained by Cramer. The metals capable of this kind of granulation, as lead, tin, and braſs, are very brittle, when they are ſo hot as to be almoſt fuſed. The chalk with which the inſide of the box is rubbed, encreaſes the reſiſtance to the motion of the agitated metal, and preſerves the box from being burnt. When the melted metal is ſhaken and daſhed againſt the ſides of the veſſel, it no ſooner becomes ſolid, and conſequently exceedingly brittle, than it is ſhivered into a fine duſt. Thoſe metals which are rendered more tenacious by being heated almoſt to fuſion, as gold and ſilver, muſt evidently be incapable of this kind of granulation.

The other method of granulation may be performed by pouring the metal upon a broom, interpoſed betwixt it and the water, by which means the fluid metal is divided into ſlender ſtreams which are further broken by the circular motion of the water. See a deſcription of an apparatus for granulating copper for the purpoſe of making braſs, in a note to the article Brass. Melted metals may alſo be granulated by being poured from a certain height into a veſſel of water, or of other fluids capable of fixing by their coldneſs the drops as ſoon as they fall, and thereby preventing them from again running together into large maſſes. This granulation may be thus explained. The ſeveral parts of a fluid poured out of a veſſel, begin their falls at ſucceſſive inſtants of time. The velocity acquired by each of theſe parts from the accelerating power of gravity, is proportionable to the time from the beginning of its fall. This acceleration of velocity produces a continual increaſe of the interval or ſpace betwixt any two parts of a fluid, which have begun to fall at different times. Hence the ſeveral parts of a falling fluid tend to ſeparate from each other, or to form diſtinct maſſes or drops; and they accordingly do ſeparate, when this tendency is ſtronger than the force of coheſion by which they are held together.

is, their weight, or the constant effect of the gravity of any certain quantity of matter. Thus we judge, that the quantities of any two substances, however dissimilar, are equal, if they produce equal effects of gravity. The weight, therefore, and the quantity, of a substance are the same thing. Men have agreed to determine the weights and quantities of matter of all substances by certain effects of gravity, and have given different names to more or less considerable weights, as *grains*, *drams*, *ounces*, *pounds*, &c. so that two quantities of different substances, which produce the same effect of gravity, that is, of a grain, or of a dram, of an ounce, &c. are justly considered to be equal. In this sense we say, that a pound of lead is not heavier than a pound of cotton. This absolute gravity, weight, or quantity of matter of any body, is measured by means of an ordinary ballance, which is a lever suspended freely on its center of gravity, which ought to be exactly in the middle of its length. Two quantities of matter, being suspended at the two extremities of the lever, are considered as equal, or of the same weight, when this lever maintains itself in an horizontal direction.

This is the best and justest method to determine the quantity of matters employed. It is much used in commerce, and in the ordinary purposes of life. It is also the only one which ought to be employed in all the operations of chemistry, which require accuracy.

In the second place, we may consider a body as heavy, relatively not only to its mass or quantity of matter, but also to the space it occupies, that is, to its bulk. A great difference is found in this respect, among natural bodies. This difference proceeds from the greater or less number or size of empty spaces, called pores, which are in every body. Bodies which are not very porous, must evidently contain under the same bulk, a greater quantity of matter than those which are more porous; and consequently a body of a certain size, but not very porous, must have a greater absolute gravity than another body of the same size, but more porous. As these differences depend on the particular species of each body, gravity estimated in this manner is called *specific gravity*. It may also be called *relative*, because we judge of it by comparing bodies with one another. This gravity is the same thing as the density of bodies. The specific gravity or density therefore of bodies, consists in the relation betwixt their absolute gravity or weight and their bulk; and the specific gravity of any body is so much greater as its absolute gravity is more considerable, and as its bulk is less; or, in the language of geometricians, it is in a direct ratio of the mass, and in an inverse ratio of the size. Hence if two bodies be equal in size, they will be to each other as their real weights or masses: and if they are equal in weight or mass, their specific gravities will be reciprocally as their sizes; that is, the specific gravity of the less bulky body will so exceed that of the more bulky body, as the bulk of this latter body exceeds that of the former.

As the density of bodies is one of their internal and essential qualities, the knowledge of which contributes much to distinguish them, and to throw light upon their nature, philosophical chemists have always applied themselves to determine this matter. By this method the purity of metals, and of several other substances, the degree of concentration of acids, of liquid alkalis, of spirits, and of other solvents, may be ascertained; and thus important discoveries

may be made. For inſtance, they have diſcovered that by allaying metals and ſemimetals, metallic maſſes are formed, the ſpecific gravity of which ſeldom correſponds with what it ought to be, if theſe metals were not condenſed or expanded by the allay. Theſe experiments, however, are but yet begun; and we may preſume that in proſecuting them, the ſame phenomena will be obſerved, and perhaps ſtill more varied in the ſolutions and combinations of all other ſolid and liquid bodies, and that we may find by this means explanations of many obſcure and intereſting facts.

The ſpecific gravity of bodies may be conveniently determined by ſeveral methods. As this gravity is only relative, and can be eſtimated by compariſon only, a ſubſtance ſimple and invariable, or which at leaſt might eaſily be made as pure as poſſible, was judiciouſly choſen, to the weight of which the weight of all other ſubſtances might be compared. All theſe conditions are found in pure and diſtilled water. Accordingly by weighing very accurately a determinate quantity, an ounce, for inſtance, of pure water in a phial, and marking preciſely the ſpace it occupies in the phial, the relation of the ſpecific gravity of any other fluid to the ſpecific gravity of this water may be eaſily determined. For this purpoſe, let ſuch a quantity of this fluid be put into the phial, that it ſhall exactly occupy the ſame ſpace which the water did, and let it be accurately weighed. As the bulk of the two ſubſtances thus compared are equal, and as their ſpecific gravities are to each other in this caſe as their abſolute weights, if the liquor compared with water weighs exactly an ounce, its ſpecific gravity will be equal to that of water; and if, on the contrary, it weighs more or leſs than an ounce, its ſpecific gravity will be ſo much more or leſs great than that of water, according as it ſhall weigh more or leſs than an ounce. If, for example, this bulk of liquor equal to that of an ounce of water, weighs two ounces, its ſpecific gravity will be double that of water; if, on the contrary, this liquor weighs only half an ounce, its ſpecific gravity will be only half as much as that of water.

This method is very juſt, convenient, and the beſt which can be employed to determine the ſpecific gravity of liquid ſubſtances, from the facility with which they may be all reduced to an equal bulk. But ſome management and addreſs are requiſite to give preciſely the ſame bulk to two ſolid bodies. To do this preciſely we may even affirm to be impoſſible; therefore another method muſt be uſed, to determine the ſpecific gravities of ſolid bodies. We have obſerved, that the ſpecific gravities of bodies of equal bulk are to each other as their abſolute gravities or weights; and upon this principle the method we have explained is founded; but that when the maſſes or weights of two or more bodies are equal, their ſpecific gravities are to each other in the inverſe ratio of their bulks. From this ſecond principle we may more eaſily determine the ſpecific gravities of ſolid bodies. The method uſed for this purpoſe conſiſts in reducing the bodies to be compared to the ſame real weight, and then in comparing their bulks to each other, or (which is the ſame thing) the effects of theſe bulks upon the ſame, or equal quantities of water, as we ſhall ſee.

When, therefore, the ſpecific gravity of two ſolid bodies is to be determined, an equal quantity, an ounce, for example, of each of them is to be weighed very accurately in the ordinary method, whatever be the difference of their bulks. Each of theſe bodies is afterwards to be weighed in pure water, by the

the *hydrostatical ballance*, and the difference between their real weights and their weights when they are immersed in water, that is, the loss of weight which each of them sustains by this immersion, is to be observed. These losses of weight are then to be compared; and the body which has lost the least exceeds the other in specific gravity in the same proportion that the loss of weight of the latter exceeds that of the former.

To understand well what happens in this experiment, we must remark, that if a solid body be immersed in water, and if it be left in the water unsupported, and without giving it any impulse, the bulk of this body will occupy the room of a quantity of water exactly equal in bulk to that of the immersed body; and if the specific gravity of this body be equal to that of the water, it will remain motionless in the same place where it was left, because its real weight being the same as that of an equal bulk of water, it remains suspended in the water, like an equal quantity of water, that is, counterpoised by the gravity of all the surrounding parts, and consequently at rest, and in an equilibrium. But if the specific gravity of this body be different from that of water, then no equilibrium can exist. If its weight be greater than that of the water, it must necessarily descend to the bottom of the vessel; and if it be less, it must rise to the surface of the water: and the force with which that body will rise or descend, will be proportionable to the difference betwixt its gravity and that of water. If, for example, when it occupies the place of an ounce of water, it really weighs two ounces, it will fall to the bottom of the vessel, but with a force only proportionate to the excess of its weight above the weight of water; for as it cannot fall without continually displacing the bulk of an ounce of water, therefore one ounce of its weight will be employed in ballancing or counterpoising an equal weight of water, and the body will descend by the effect of the weight of the remaining ounce, or with half its real weight. Hence, if that body be suspended at one of the arms of a ballance, it may be counterpoised by an ounce weight, placed in the scale suspended by the other arm of the balance, in air, and consequently it will appear to be one half less heavy in water, than in air.

This being established, as a body of a determinate weight loses so much less of this weight in water as its bulk is less, and as these two things are in the same relation, we may therefore substitute one for the other; and when we weigh in water two bodies of equal weight, we may judge of the relation of their bulks, and consequently may appreciate their specific gravities, by determining and comparing the diminution of weight which they sustain when weighed in water. This is much more easy and exact than a mensuration of their bulks. Thus, for example, if we weigh in water two bodies of equal weight, and if the one loses a tenth part of its weight in the water, and the other loses only a twentieth part, we may conclude from thence, that the bulk of this latter body is one half less than that of the former, and consequently its specific gravity is double; because the specific gravities of bodies of equal weights are in the inverse ratio of their bulks. *See what ought to be observed in weighing bodies in water, under the article* BALANCE (HYDROSTATICAL).

From what has been said concerning the gravity of bodies, we may perceive, that in examining their nature and properties, the specific gravity only of bodies is attended to; and that the absolute gravity, or rather the weights used to determine it, are things arbitrary and conventional, which, however, deter-

mine well the absolute gravity, when they themselves are determinate and accurate. But we must observe, that weights, like measures, have a great inconvenience in not being uniform. They are fixed arbitrarily and differently in different countries; so that an ounce, or a pound, is not always the same in one country as it is in another; which necessarily introduces confusion and errors in commerce and in the arts. As weights cannot be fixed but by an exact measure or bulk of the bodies intended to be used to fix these weights, the measures must evidently be first rendered uniform in all nations, which is not to be expected. The thing, however, is very possible. The length of a pendulum, which vibrates every second under the equator, is a fixed and invariable measure to which all others may be referred, and would be very proper to be universal, if nations would agree to it. This project, the execution of which would certainly be very favorable to commerce, arts, sciences, and consequently mankind, was proposed by M. de la Condamine, in a memoir which he read at the Academy of Sciences.

To compleat this article, we must examine what effects are produced by the gravity of bodies in their combinations and decompositions, that is, in all chemical operations. It is undoubtedly the most important and decisive object for the general theory of chemistry, but it is not within our province, as it cannot be well treated but by help of mathematics. In this point these two sciences, which appear so remote from each other, meet. A man sufficiently intelligent and able in both, might, by treating this matter accurately, throw much light upon it, and lay the foundation for a new physico-mathematical science; or rather, might render the application of algebra and geometry to natural philosophy much more general. Several persons, and lately Mr. Sage, in a Dissertation, which gained the prize of the Academy of Rouen, concerning the Cause of Chemical Affinities, have advanced some steps in this path; but great difficulties will probably occur. Perhaps chemistry is not yet sufficiently advanced to be subjected to calculation; perhaps even it will never be so far advanced; and although men of genius have, since the restoration of the sciences, carried mathematics to a greater perfection than it was believed could have been attained, the problems which chemical phenomena offered to geometricians may be so complicated, as to be above the reach of human understanding.

However that may be, in these latter ages a most happy application has been made of the theory of universal gravity to the system of the world, and to explain very satisfactorily the celestial phenomena. If this universal gravitation of the heavenly bodies, so happily observed, and so well calculated, be an essential property of matter in general, as many reasons induce us to believe, its effects cannot be confined to very large bodies separated from each other by immense distances, but must necessarily act likewise the small particles of matter at very small distances from each other, and consequently in chemical combinations and solutions. Although we do not precisely know the bulks, the masses, the forms, nor the distances of the integrant and constituent parts of bodies, we see them act upon each other, unite or separate, adhere more or less strongly, or resist all union; and we must believe that these effects are produced by the same power; such, for example, as the reciprocal gravitation of these small particles to each other; which is variously modified, according to their

size,

fize, their denfity, their figure, their extent, the intimacy of their contact, or the greater or lefs diftance of their approach.

By telefcopes and other inftruments, aftronomers have indeed difcovered the fize, diftance, and motions of heavenly bodies; and by applying calculation and geometry to thefe difcoveries, they have perceived the gravitation of thefe great bodies, and have even determined the law of that gravitation: but the microfcope has been found ineffectual to fhew the primary and elementary parts of bodies; and when geometricians have endeavoured to apply the theory of univerfal gravitation to the phenomena of terreftrial bodies, they found that this gravitation did not follow the rule of the inverfe ratio of the fquare of the diftance, when this diftance was very fmall. The law of gravitation in fmall diftances does not appear to have been yet well determined; whether this proceeds from a want of a fufficient number of facts, or becaufe it has not been examined by the ableft geometricians. But although we cannot precifely determine this point, would it not be defirable to approximate it indirectly, and by making fuppofitions? This appears fo much the more eafy, as the velocities, the times, the fpaces paft, need not be obferved and calculated, nor periodical revolutions to be determined: for the motions of the elementary parts of bodies, although certainly very regular, and fubjected to the fame fixed laws, cannot be perceived minutely, and only by their effects. They are made in indivifible inftants. They are not conftant, but perpetually variable, according to the circumftances which determine them. We cannot therefore confider thefe objects but in general, or rather in a vague manner. But, however, I afk thofe who are capable of deciding fuch queftions, if, fuppofing that the fmalleft atoms of matter are affected by the fame power by which the heavenly bodies gravitate to each other, may we not confider their tendency to the center of the earth as of no effect, when we attend to the almoft infinite fmallnefs of thefe elementary particles, and the infinitely fmall diftance at which they may approach each other? The effect of their gravity ought in this cafe to be, to make them tend to each other. They are, as it were, fmall worlds feparated from the reft; or, being at liberty to yield to their reciprocal tendency, they re-act upon each other, without being difturbed by the great counterpoife which keeps the whole univerfe in an equilibrium. In the fecond place, as the diftance betwixt thefe molecules of bodies is infinitely fmall, or none at all, may not contact be fubftituted for it? And in this cafe, would not the force with which thefe molecules tend to each other, or adhere together, be in a compound ratio of their denfities and contacts? Hence it fhould follow, that bodies whofe primary integrant molecules fhould have the greateft denfity, and whofe figure fhould allow them to have the moft extenfive and immediate contact, would be the hardeft of all bodies, or thofe whofe aggregation would be the firmeft; fuch, for example, as we conceive that of vitrifiable ftones to be: and that, on the contrary, bodies whofe primary integrant molecules fhould have the leaft denfity, and fuch a figure that they could not have but the fmalleft poffible contact, would be the leaft hard of all bodies, or rather would be fluid; fuch pure fire appears to be, and the other fubftances effentially fluid, if any fuch are.

In the third place, if we fuppofe fubftances whofe primary integrant molecules have a very great denfity, but can have only very fmall contacts; whether that may depend on their figure, or the interpofition of fome other fubftance with the

the parts of which they can also have but small contacts; then we may evidently perceive, that the force with which these molecules tend to unite together will not be satisfied, and consequently will be in a continual nisus or effort, and, if we may be allowed to say it, in a state of violence; so that when they shall have within their reach any other substance upon which they may exercise the tendency which they have to unite with that substance; that is, with which they shall have a greater contact; they will then actually unite with that substance with an activity and impetuosity proportionate to their remaining tendency to unite, or their unsatisfied gravitation. Such appear to be mineral acids, and in general all chemical solvents; the action of which cannot be conceived, unless we suppose that the force with which their integrant parts tend to unite with the particles of the bodies which they dissolve, is much greater than the force with which these latter are kept united.

Hence, if the parts of the dissolved body be so dense, or be capable of having such contact with the parts of the solvent, that the activity of these latter parts shall be entirely satisfied by their mutual union; the solvent will then be in a state of rest, or in a kind of equilibrium, and will have no more dissolving power. This is called in chemistry the *state or point of saturation*. To make this saturation compleat, each of the integrant parts of the solvent must have met an integrant part of the dissolved body, upon which it may exhaust all its activity.

If, on the contrary, the parts of the dissolved body be not sufficiently dense, and cannot have a sufficient contact with the parts of the solvent to satisfy entirely all the tendency of these latter; from such a combination, an imperfect saturation only of the solvent will result, and it will still retain force enough to act upon other bodies. This may be observed in the neutral deliquescent salts, and other combinations of this nature. *See* SALTS, *and* DELIQUESCENCE.

Fourthly, we may perceive from what has been said, that the force which makes the integrant and constituent parts of bodies tend to each other, although much superior to their gravitation towards the center of the earth, is however limited; that it must be very variable in its effects, and even of no effect in certain circumstances. In the same manner as the adherence of the integrant parts of a body which yields to the action of a solvent, ought not to be considered as any thing in comparison of the force which makes them tend to the parts of this solvent; so that after the solution they cannot any longer be united together, but only to the parts of this solvent; so in the same manner, I say, we may conceive that the force which unites the principles of a compound body to each other ought to become ineffectual, when, on one side, the tendency of the parts of these principles is entirely exhausted by their union; and when, on the other side, to this compound is applied another body, with the parts of which those of one of the principles of the compound may contract an union, infinitely superior to that which they had with the parts of the other principles of the compound. In this case, the principles of the compound must evidently be disunited; one of these principles must form a new compound with the new substance applied to it, and the molecules of the other principles, being now disengaged, must exercise their tendency upon each other, and form small aggregates; which, when they have arrived at a certain mass, must yield to the gravity

gravity by which they tend to the center of the earth. Thus we may conceive how *precipitations* are effected.

This will become clearer by an example; and for this purpose, let us choose a compound, such as that which results from the union of nitrous acid with silver. From experience we know that when copper is applied to this compound, the nitrous acid quits the silver to combine with the copper, with which it forms a new compound; and that silver thus separated from this acid, by the presence and contact of the copper, has no longer any adherence with the acid, unites again into larger molecules, the mass of which becomes so large, that they cannot yield to any other tendency than to the general gravitation which all bodies of a certain mass have towards the center of the earth; and accordingly we see the molecules of silver fall to the bottom of the vessel in which this operation is made. I say, first, that we cannot conceive what happens in this operation, unless we suppose that the force which unites the parts of the silver with those of the nitrous acid evanishes, or becomes ineffectual, in comparison of that force which tends to unite, and which does unite, these parts of the nitrous acid with the parts of the copper. In the second place, supposing always that all chemical combinations and decompositions are the effects of a mutual and particular gravitation of the integrant and constituent parts of bodies to each other, which is in a ratio of the density and contact of these same parts; I say, that if in the present case, the parts of the nitrous acid quit the silver to unite with the copper, the integrant parts of this latter metal must have infinitely more density, or must be capable of having a much more extensive and intimate contact with the parts of the nitrous acid than those of the silver. Whence the action of the parts of the nitrous acid, which is only very imperfectly satisfied by their union with the parts of the silver, is in some measure exhausted by the new union with the parts of the copper; so that only an infinitely small force of adhesion to the parts of the silver remains; and then we may easily conceive that the tendency of the parts of the silver to each other may be more than is sufficient to overcome this slight adhesion; and consequently the parts of silver may really separate from the nitrous acid, and may form sensible masses capable of yielding to the general gravitation to the center of the earth.

Hence also, if, at the same time that the parts of the nitrous acid are determined by the presence and contact of the parts of the copper, to separate from those of the silver, these parts of silver shall find within their reach some other substances, with the parts of which they have a still greater disposition to unite than with each other; they will unite with this substance, and form a new compound; which circumstance ought to facilitate the separation of silver from the nitrous acid; and which also, when the silver has a strong affinity with the matter presented to it, might effect the same decomposition, although even the copper had not a sufficiently strong affinity with the nitrous acid to separate it from the silver. This seems actually to happen in the case of two new decompositions and combinations, which can only be performed by *double affinities*.

All the other phenomena which happen in chemical combinations and decompositions may be easily deduced from the suppositions we have made, and are only the necessary consequences of these suppositions. For these phenomena, we refer to the articles Affinity, Aggregation, Composition, Combination, Decomposition, Solution, Precipitation, *and* Precipitates.

I am

I am sensible that this interesting matter is liable to great difficulties and objections, and is here but superficially treated. Perhaps time, experience, the encrease of chemical knowledge, lastly, the zeal of persons skilled in mathematics and chemistry, will hereafter throw much more light upon these subjects, of which now we have but confused notions. However, I cannot but consider them as the true key of the most hidden phenomena of chemistry, and consequently of all natural philosophy.

CCCLVI. GREAT WORK. The great work is the alchemical process by which gold is made, or pretended to be made.

CCCLVII. GRITT-STONE. (s)

CCCLVIII. GUMS. Gums are mucilaginous juices which separate spontaneously from several plants or trees, and which have acquired a solid consistence by the evaporation of the greatest part of their superabundant water. Formerly all concrete juices collected from trees, whatever their nature was, were called gums. Hence many of these juices, which are entirely or partly resinous, are still called gums; such are *gum copal*, *gum elemi*, *gum anime*, *gumma gutta*, and many others: but modern chemists and naturalists have with propriety considered only the concrete mucilages soluble in water as true and pure gums. We shall therefore treat of these gums only in this article.

Gums have a firm and solid consistence, a certain degree of elasticity, and great tenacity of their parts. These latter properties render them capable of resisting percussion without being broken; by which they are rendered very difficultly pulverisable in a mortar. They are more or less white and transparent: some of them, nevertheless, are of a yellow or brown color, but the matters by which they are colored are foreign to them. Very pure gums have no smell, scarcely any taste, or a very mild and slight taste. They are not soluble, either by oils, or by spirit of wine, but are perfectly soluble in water; and when the quantity of water used for this solution is but moderate, they form with it a thick, viscid, transparent fluid, and they again become mucilages, such as they were originally.

Although gums are obtained from many trees and plants of very different kinds, all gums, nevertheless, are very similar, and do not properly differ from each other but by the quantity of mucilage which they are capable of forming with water. Three principal kinds of gums are distinguished. These are *gum tragacanth*, *gum arabic*, and *ordinary gums*.

Gum tragacanth issues from a thorny shrub called *tragacanth*, which grows in Syria and other oriental countries. It consists of small twisted bits, the surfaces of which, when broken, are shining. It contains more mucilage, and is therefore dearer than any other gum.

Gum arabic is obtained from a kind of acacia, and perhaps from several other trees which grow in Arabia and in Africa. It consists of round, rough pieces; some of which are beautiful, white, and transparent.

(s) GRITT-STONE is a stone consisting of particles of sand agglutinated together. The differences of these stones proceed from the different sizes of the particles of sand composing them, the different properties of these sands, and their different degrees of compactness and of agglutination. Some of these stones are employed for building, others for grinding, others for whetting sharp steel instruments, and others for filtrating water.

Ordinary

Ordinary gums are those which are gathered from most fruit-trees; such as almond, apricot, plumb, and cherry trees, &c. It is generally less white and less transparent than gum arabic, though sometimes it is as beautiful. Druggists pick the best pieces of these gums, and sell them for gum arabic; from which no inconvenience proceeds, as they do not essentially differ from that gum.

As gum and mucilage are only one and the same substance united with a greater or less quantity of superabundant water, these matters have absolutely the same properties, and in their analysis furnish the same principles. For a further knowledge, therefore, of the nature of gums, we refer to the article MUCILAGE.

CCCLIX. GUM-RESINS. Gum-resins are juices, partly mucilaginous and partly oily, which flow from many kinds of trees, and which become concrete by the evaporation of their finest fluid parts.

The oily and mucilaginous parts which form gum-resins are intimately mixed, but not absolutely combined with each other: hence these concrete substances are not perfectly soluble, either by water, by oils, or by spirit of wine, singly. When indeed any of these solvents, for example, water, is applied singly to most gum-resins, and when the action of such solvent is assisted by trituration, a kind of solution is effected. The gummy part is entirely soluble in water, and forms a mucilage with it; while the resinous part, which was originally much divided and intimately mixed with the gummy part, remains suspended in the water, and consequently forms a kind of milk or emulsion: but this oily part is then evidently divided only, but not dissolved. *See* EMULSION. Thus the gum-resin is reduced nearly to its original state; I say, nearly, because the oily substance loses by drying its most fluid and volatile part, which is not restored to it by treating it with water in the manner above-mentioned.

We may also make a kind of solution of these gum-resins, by employing solvents, which are partly watery, and partly oily or spirituous; such as wine, vinegar, or aqua vitæ; but these solutions are always milky, from the water which hinders the spirituous part from combining intimately with the resin. To dissolve, therefore, completely a gum-resin, the resinous part must be separated from the gummy part, by applying alternately a spirituous menstruum, and a watery menstruum.

From these properties of gum-resins, relating to their solubility, chemists have discovered their true nature; for from most of their other properties, and particularly from their external appearance, they might be confounded with pure resins, to which they have a strong resemblance. Here we ought to remark, that the proportion of the gum and of the resin is not constantly the same in different gum-resins, in some of which the gummy part is very small in proportion to the resinous: hence, upon a more particular examination of the concrete juices which issue from trees, many of them are classed among the gum-resins, which formerly had been considered as pure resins; and this subject is still very uncertain. Nevertheless, as all gum-resins are mixtures of substances which are not mutually soluble by each other; and as from such a mixture the compound bodies which result must be opake; we may discover, merely by the view, whether any concrete juice be a gum-resin or not. All those which are opake, or are not evidently transparent, may reasonably be suspected to be of a gummy-resinous, or extractive resinous nature. Of this kind are

myrrh, *bdellium*, *ſagapenum*, *opoponax*, *aſſa-fœtida*, and others which are evidently gum-reſins. On the contrary, all thoſe which are very tranſparent may be certainly conſidered either as pure gums or pure reſins: ſuch are the gums *tragacanth* and *arabic*; and the pure reſins *maſtic*, *ſandarac*, *gum-copal*, and other diaphanous ſubſtances, which may be diſcovered to be pure reſins, and diſtinguiſhed from pure gums, by their ſmell, inflammability, and other qualities peculiar to oily matters.

This rule, which certainly may be uſeful in determining without trouble concerning the nature of concrete juices, ought not to prevent us from making other ſuitable trials, and particularly thoſe by applying different menſtruums, when we would certainly determine the nature of the matter to be examined. Theſe trials are particularly neceſſary for thoſe concrete juices which are but little tranſparent, and are ſtrongly colored. Such are *gum-lac*, *gumma gutta*, *ſanguis draconis*, *aloes*, *opium*: for theſe latter concrete juices are ſtill more compounded than pure gum-reſins, and contain different coloring and extractive matters. *See* OILS, MUCILAGE, EXTRACTS, EMULSIONS, GUMS, *and* RESINS.

CCCLX. GUN-POWDER. *See* POWDER.

CCCLXI. GUYAC. Guyac is a very hard, heavy, compact wood of a tree which grows in hot countries, particularly in the Antilles Iſlands, and in other parts of America. It contains much reſin, which may be extracted from it by ſpirit of wine, in the ſame manner as the reſins of jalap, turpentine, &c. may be extracted from the vegetables which contain them. *See* ANALYSIS *by* MENSTRUUMS, *and* RESINS.

Guyac wood, when diſtilled with a heat not exceeding that of boiling water, is not, properly ſpeaking, decompoſed; ſince nothing paſſes over but a pure, or almoſt pure, phlegm, which ſeems to be nothing elſe than the ſuperabundant water it contains: a naked fire, therefore, is neceſſary for the decompoſition of this and all other woods. When guyac is to be diſtilled, it is to be cut into thin ſhavings, and put into a ſtone-ware retort; to which is to be adapted a large glaſs receiver with a ſmall hole pierced in its ſide; and the diſtillation is to be promoted by a graduated fire. At firſt, a liquor almoſt purely watery is obtained; and then, upon encreaſing the fire, an acid, reddiſh, empyreumatic liquor paſſes over, together with a little fluid reddiſh oil. Theſe reſults riſe in white vapors, and, at the ſame time, a conſiderable quantity of air is diſengaged, which would burſt the receiver, if it was not allowed to eſcape through the ſmall hole, which is ſometimes opened for that purpoſe. The acid and oil continue to riſe thus to the end of the diſtillation; the acid becoming ſtronger and ſtronger, and the oil becoming more and more empyreumatic, black, and thick; ſo that, at laſt, its conſiſtence is equal to that of turpentine. Laſtly, when the retort is thoroughly red-hot, the diſtillation is finiſhed. In the retort, the ſhavings of guyac are found reduced to perfect coal; but ſtill retain their original form. The acid, called alſo the *ſpirit*, and the oil are found together in the receiver, and may be ſeparated from each other by a funnel.

This analyſis of guyac is well known by chemiſts, becauſe the empyreumatic oil produced was one of the firſt which was obſerved to be capable of inflammation by mixture with ſpirit of nitre; and becauſe this analyſis is generally given as an example of the diſtillation of vegetables with a naked fire.

Thus,

Thus, for inſtance, all the odoriferous plants from which the ſpiritus rector, eſſential oil, and other volatile principles, have been extracted by a degree of heat not exceeding that of boiling water, being afterwards diſtilled with a naked fire, without which they cannot be decompoſed, yield principles analogous to thoſe obtained from guyac wood.

The analyſis of guyac wood exhibits ſome phenomena deſerving attention. The great quantity of air diſengaged during this operation is very remarkable. It proves that this element is truly combined in certain bodies, and particularly in this; that is to ſay, that its integrant parts are diſunited from each other, and adhere to ſome of the united parts of the guyac. This is proved by the long time during which the air diſengages itſelf from the guyac; for this element being much more volatile than water, if it was not combined and retained by ſome fixed principle to which it is united, it would be ſoon diſengaged, and with a heat much leſs than that which is ſufficient to raiſe the ſuperabundant and uncombined water of the guyac. Beſides, this air ſeems to be deprived of its elaſticity while it remains in this compound; otherwiſe, it could not be condenſed into ſo ſmall a ſpace, but by a violent compreſſion. But this privation of the elaſticity of the air proves alſo that its aggregation is broken, in the ſame manner as the phlogiſton, or combined fire, has neither light, heat, nor fluidity, which are properties eſſential to it, when it is in its ſtate of aggregation.

The acid obtained in diſtillation with a naked fire from guyac and other ſimilar vegetables is ſtill united, and even intimately, with a conſiderable portion of oil. This appears from its color, and particularly from its empyreumatic ſmell; for this ſmell cannot be contracted by any thing but oil: beſides, the acid may be deprived of much of this empyreumatic oil, by further operations, and particularly by ſaturating it with alkalis, from which it may be afterwards ſeparated by a ſecond diſtillation. In both theſe operations much of the oil is ſeparated, and thus the acid is rectified.

This portion of empyreumatic oil is found to be well combined with the acid after the firſt diſtillation; for it no longer diſturbs its tranſparency, even when it is mixed with much water; becauſe the acid ſerves as an intermediate ſubſtance to keep the oil and water ſuſpended or diſſolved.

This rectification of empyreumatic vegetable acids has not been carried ſo far by chemiſts, as it might be.

The oil obtained in this diſtillation is acrid and empyreumatic, it being one of thoſe which are incapable of being diſtilled but by a heat much ſuperior to that of boiling water, by which heat all oils are much altered, acquire a burnt and empyreumatic ſmell, and allow much of their acid to eſcape. *See* OIL. The oil of guyac is employed, as all thoſe equally acrid, to facilitate the exfoliation of carious bones.

Laſtly, the coal found in the retort is a perfect coal, when the diſtillation has been continued till the retort has been red-hot; otherwiſe the reſiduum would contain ſome thick and half-burnt oil; but it is contrary to the nature of coal to contain any oil. *See* COAL.

CCCLXII. GUHR. (t)

(t) GUHR, *Creta fluida*, *Medulla fluida*, *Marga fluida*. Thoſe names are given to a liquid calcareous or chalky ſubſtance, white or aſh-colored, found generally in mines and

 ſubterranean

CCCLXIII. GYPSUM. Gypſum is a ſoft, friable, ſtony matter, which does not ſtrike fire with ſteel. It is found in large quantities in many parts of the earth, forming large mountains, and very extenſive chains of mountains and hills, as in the neighbourhood of Paris.

Gypſum is always cryſtallized, or regularly diſpoſed. In its cryſtallization it affects ſeveral different forms. The firſt form is that of large, tranſparent, ſhining, thin laminæ applied to each other, ſo exactly, that they conſtitute maſſes as tranſparent as cryſtal. Theſe are called by naturaliſts, *lapis ſpecularis*, from their large ſhining ſurfaces, like thoſe of mirrors.

In the ſecond place, a large quantity of gypſum is found cryſtallized in ſtriæ, like threads applied longitudinally to each other. This is called *ſtriated gypſum*. Laſtly, a very large quantity of gypſum is found in ſmall irregular cryſtals, agglutinated to each other, forming conſiderable maſſes of ſemi-tranſparent granulated ſtones, commonly called *gypſeous alabaſter*, when they are very white and pure, which gives them a more beautiful and perfect ſemi-tranſparency. *See* ALABASTER. (*u*)

All theſe gypſums, although very different in external appearance, are perfectly ſimilar as to their chemical and eſſential properties.

When expoſed to a very moderate heat, they quickly loſe their tranſparency, and acquire an opake white color. They alſo become very friable by expoſure to this heat, and the laminæ of the lapis ſpecularis ſeparate from each other.

Gypſum in this ſtate, mixed and kneaded with water, forms a kind of mortar, which ſoon hardens into a ſolid body. This property renders it very uſeful for buildings, in the conſtruction of which it is employed under the name of *plaſter*. And, in fact, nothing can be more convenient than a ſtone which in its ſoft ſtate is capable of receiving any form, which it afterwards preſerves many years by its property of hardening.

The properties above-mentioned are peculiar to gypſeous matters, and diſtinguiſh them from *talcs*, *amianthus*, *asbeſtus*, with which they frequently have an external reſemblance.

Gypſum by other properties reſembles calcareous earths. Thus, when it is calcined and put into water, a pellicle like the cream of lime is formed upon the ſurface of the water. This water makes the ſyrup of violets green, as lime-water does. Laſtly, gypſum acts a little upon ſulphur, and makes it a kind of earthy hepar of ſulphur, as quicklime does: but, nevertheleſs, gypſeous and calcareous ſtones ought not to be confounded together.

Gypſum differs from calcareous earth in this, that it does not diſſolve and effervеſce with acids. Mr. Pott obſerves, that vitriolic and nitrous acids being treated with gypſum, do not loſe their acidity; whereas theſe acids are eaſily

ſubterranean places, where it drops and forms ſtalactitical concretions. There are alſo *metallic guhrs*, or liquid maſſes, ſometimes found in mines, containing metallic particles; and which, by dropping, form metallic ſtalactitical concretions.

(*u*) Beſides the gypſums above-mentioned, a rhomboidal gypſeous ſtone is found, called alſo *ſelenites*, ſometimes laminated, and ſometimes not. It is diſtinguiſhable from rhomboidal calcareous ſpars by the general properties of gypſeous earths, and by its truncated angles. Other gypſums are found, conſiſting of differently formed cryſtals, as hexagonal parallelipipedons and pyramids.

neutraliſed

neutralised by calcareous earth, with which they form neutral salts with earthy bases. Mr. Beaumé remarks, that gypsum may indeed be dissolved in some measure by acids; but that the gypsum thus dissolved is afterwards separated by crystallization, and is in the same state as it was before that solution, without retaining any part of the acids. Besides, quicklime does not harden, as gypsum does, without addition of sand or cement.

These differences are sufficient to distinguish gypseous from calcareous earths. But this distinction is further established by experiments which have been lately made by chemists to determine the nature of gypsum.

Mr. Pott, in his Lithogeognosia, places gypsum amongst the four principal kinds of earths, to which he refers all the others, and consequently distinguishes it very accurately from the three other principal earths, and particularly from calcareous earth. He relates in that work many experiments made upon gypsum, to shew its nature and properties. Gypsum, according to him, cannot be fused without addition by the most violent fire of furnaces. Some chemists had affirmed that it was fusible by the heat of solar rays collected by mirrors. Mr. Pott did not repeat that experiment.

I have exposed lapis specularis to the focus of a good burning mirror; and I remarked, that while the focus of rays fell upon its flat surface, the stone was only calcined, and not fused; but that when the focus was applied to the side of the stone formed by the edges of the plates or laminæ placed upon each other, this gypsum was immediately fused with a considerable ebullition. *(x)*

From Mr. Pott's experiments we chiefly learn, that gypsum or gypseous alabaster, (for that was the kind which he made the subject of his experiments) may be fused and vitrified when mixed with argillaceous earths, to which it serves as a flux, as calcareous earth does: but in this fusion with argillaceous earth, gypsum bubbles and swells much more than pure calcareous earth does.

This fusion of clay procured by gypsum, as by calcareous earth, as well as the other properties common to gypsum and calcareous earth, are occasioned by the greatest part of the gypsum being really composed of calcareous earth, which earth has been proved to be united in this compound with vitriolic acid. Mr. Macquer, in his Memoir upon Quicklime and Plaster, printed amongst the Memoirs of the Academy for the year 1747, mentions the vitriolic acid as one of the constituent parts of gypsum.

Mr. Pott, in his Lithogeognosia, says, that several Authors rank amongst gypsums a composition resulting from the union of vitriolic acid with a calcareous earth; and that they call this compound *selenitic earth*, or *artificial gypsum*. Although Mr. Pott found some slight differences betwixt this compound and natural gypsum, yet the former had all the essential properties of the latter.

Mr. Macquer, treating of hard waters, in his Elements of Chemistry, says, that their hardness is occasioned by a gypseous selenites which is dissolved in

(x) From Mr. D'Arcet's Memoir upon the Effects of violent and long-continued Heat, we find that all gypseous stones and earths are fusible by the fire of furnaces. This, however, we may observe concerning the fusibility of gypsum, that if it be exposed long to a moderate fire not sufficient to fuse it, much of its vitriolic acid will be expelled, and part of it will be reduced to a calcareous earth, as unfusible as chalk, or the other earths of that kind; therefore, a violent heat suddenly applied is necessary to the fusion of gypsum.

them.

them. Laftly, Mr. Margraaf fays, that from gypfum diftilled with powder of charcoal he obtained a volatile fulphureous acid and true fulphur; that having treated it with the alkali of tartar, by the dry and by the humid way, he obtained from it a vitriolated tartar; that the remaining earth was calcareous; that gypfum is entirely foluble in water; and that it may be artificially compofed by faturating vitriolic acid with calcareous earth. *Opufc. Chem.* 13 *Diff*

We may then confider, that gypfum has been demonftrated to be nothing elfe than calcareous earth faturated with vitriolic acid. It is a vitriolic falt with bafis of calcareous earth; that is, it is a true *felenites*. *See* SELENITES

From this account we may explain all the properties of gypfum. Its want of hardnefs, its tranfparency, its cryftallization, its folubility in water, proceed from its faline character. It cannot be combined with any acid, becaufe it is naturally faturated with the vitriolic acid. It requires much water to diffolve it, which proceeds from its felenitic quality; that is, from the great quantity of earth which it contains, and the intimacy with which this earth is united with the vitriolic acid. Its calcination, by which the cohefion of its parts are deftroyed, is nothing elfe than the fubftraction of the water of its cryftallization. *See* CRYSTALLIZATION.

The properties of quicklime which gypfum acquires by calcination, ought alfo to be attributed either to the fuperabundant calcareous earth which it may contain or rather to the fubftraction of a portion of the vitriolic acid, which is difengaged during the calcination, chiefly by touching fome inflammable matters, with which this acid unites and forms fulphur. Laftly, the hardening of plafter, when calcined and mixed with water, may proceed from a mixture of thofe parts, which by calcination have become quicklime, with thofe other parts which have not acquired that quality, and which ferve to the former as a cement, as Mr. Macquer conjectures in the above quoted memoir (*See* QUICKLIME): or elfe this hardening proceeds from the gypfum refuming the water of its cryftallization, and again cryftallizing precipitately and confufedly, as many chemifts think, and particularly Mr. Pott, who fays, " As plafter mixed with water " does not harden, but when it is left at reft, (for if it be ftirred too long, it " will not become hard) we ought to conclude, that in this cafe a cryftalli- " zation very fuddenly happens, which confequently fuppofes a very divided " faline fubftance, uniformly diffufed through the plafter, as Stahl has obferved. " This alfo is the reafon of the want of durability of plafter in the air; becaufe " the air alters and attacks the faline fubftance which it contains."

Some chemifts and naturalifts have given to gypfum the name of *fpar*, or rather diftinguifh a kind of fpar by the appellation, *gypfeous*; becaufe this fpar has the principal properties of gypfum. *See* SPAR.

CCCXLIV.

H.

CCCLXIV. HARDNESS. Hardneſs is a quality of certain bodies which conſiſts in an intimate union and ſtrong adheſion of their integrant parts, which cannot therefore be eaſily disjoined.

We cannot preciſely determine what diſpoſition of parts occaſions the greateſt hardneſs: but this probably depends on the perfection and extent of the contact of theſe parts; and this quality depends eſſentially upon their figure, which we do not know.

The hardeſt bodies which we know are vitrifiable ſtones; and amongſt theſe, the hardeſt are thoſe which are the moſt pure and homogeneous; that is, diamonds.

Not any one of all known bodies is perfectly hard. Perfect hardneſs belongs undoubtedly to the primary, elementary, and conſtituent parts of matter, which of all beings we know the leaſt of.

CCCLXV. HELLEBORE. *(y)*

CCCLXVI. HEMATITES. *(z)*

(y) HELLEBORE. Two ounces of the root of *white hellebore* yielded, with water, nine drams and a ſcruple of gummy extract; and the ſame quantity of root yielded with ſpirit of wine ſeven drams of reſinous extract. From ſix ounces of the root of *black hellebore*, ſix drams and a ſcruple were extracted by ſpirit; and from the ſame quantity of root ſix drams and two grains were extracted by water. Borrichius relates, that the diſtilled water of the whole plant poſſeſſes emetic and purgative qualities.

(z) HEMATITES, or *Bloodſtone*, is a hard mineral ſubſtance, red, black, or purple; but the powder of which is always red; ſometimes of an intermediate figure, and ſometimes ſpherical, ſemi-ſpherical, pyramidal, or cellular, that is, like a honey-comb; conſiſting of pyramids generally ſmall, the apices of which appear, in a tranſverſe ſection, in the center. It contains a large portion of iron. Forty pounds of this metal have been extracted from a quintal of the ſtone. But the iron is obtained with ſuch difficulty, and is of ſo bad a quality, that this ore is not commonly ſmelted. The great hardneſs of hematites renders it fit for burniſhing and poliſhing metals.

CCCLXVII. HEPAR. *(a)*

CCCLXVIII. HETEROGENEOUS, *and* HOMOGENEOUS. Heterogeneous ſignifies of different natures; and homogeneous ſignifies of the ſame nature.

CCCLXIX. HOPS. *(b)*

CCCLXX. HYDROMEL. Hydromel is honey diluted in nearly an equal weight of water. When this liquor has not fermented, it is called *ſimple hydromel*; and when it has undergone the ſpirituous fermentation, it is called the *vinous hydromel*, or *mead*.

Honey, like all ſaccharine ſubſtances, vegetable or animal, is ſuſceptible of fermentation in general, and particularly of the ſpirituous fermentation. To induce this fermentation, nothing is neceſſary but to dilute it ſufficiently in water, and to leave this liquor expoſed to a convenient degree of heat. To make good vinous hydromel, or mead, the whiteſt, pureſt, and beſt-taſted honey muſt be choſen, and this muſt be put into a kettle with more than its weight of water; a part of this liquor muſt be evaporated by boiling, and the liquor ſcummed, till its conſiſtence is ſuch, that a freſh egg ſhall be ſupported upon its ſurface without ſinking more than half its thickneſs into the liquor; then the liquor is to be ſtrained, and poured through a funnel into a barrel: this barrel, which ought to be nearly full, muſt be expoſed to a heat as equable as is poſſible, from 20 to 27 or 28 degrees of Mr. Reaumur's thermometer, taking care that the bung-hole be ſlightly covered but not cloſed. The phenomena of the ſpirituous fermentation will appear in this liquor, and will ſubſiſt during two or three months, according to the degree of heat; after which they will diminiſh and ceaſe. During this fermentation, the barrel muſt be filled up occaſionally with more of the ſame kind of liquor of honey, ſome of which ought to be kept apart on purpoſe to replace the liquor which flows out of the barrel in froth. When the fermentation ceaſes, and the liquor has become very vinous, the barrel is then to be put in a cellar and well cloſed. A year afterwards the mead will be fit to be put into bottles.

The vinous hydromel or mead is an agreeable kind of wine; nevertheleſs it retains long a taſte of honey, which is unpleaſing to ſome perſons; but this taſte it is ſaid to loſe entirely by being kept a very long time.

The ſpirituous fermentation of honey, as alſo that of ſugar, and of the muſt of vinous liquors, when it is very ſaccharine, is generally more difficultly effected, requires more heat, continues longer, than that of ordinary wines made from the juice of grapes; and theſe vinous liquors always preſerve a ſaccharine taſte, which ſhews that a part only of them is become ſpirituous. The cauſe of this probably is, that they contain leſs acid, or that they contain an acid leſs diſengaged than the muſt of ordinary wine. *See* FERMENTATION *and* WINE.

(a) HEPAR. *See* LIVER.

(b) HOPS are uſually added to malt liquors, and are ſaid to render theſe liquors leſs apt to become ſour, leſs viſcid, and more wholeſome by their aromatic bitterneſs. They contain a ſubtle odorous principle, which promotes the vinous fermentation. When infuſed, or but ſlightly boiled in wort, they encreaſe its ſpirituoſity. *Neuman.*

CCCLXXI. HONEY. Honey is a saccharine fermentable juice collected by bees from flowers. *For the nature and properties of honey see* SUGAR.

CCCLXXII. HORN *of* ANIMALS. The horn of animals is of the same nature as their gelatinous matter, and is only that matter charged with a less quantity of water, with a larger quantity of earth, and sufficiently condensed to have a firm and solid consistence. By digesting horn with water in Papin's digester, it may be entirely converted into jelly.

Horn is a perfectly animalised matter, and furnishes in distillation the same principles as all animal matters; that is, at first a pure phlegm, with a degree of heat not exceeding that of boiling water; then a volatile alkaline spirit, which becomes more and more penetrating and strong; a fetid, light, and thin oil; a concrete volatile salt, which forms ramifications upon the sides of the receiver; much air; fetid oil, which becomes more and more black and thick; and lastly, it leaves in the retort a considerable quantity of almost incombustible coal, from which, after its incineration, scarcely any fixed alkali can be obtained.

Animal oil, and particularly that which is drawn first in the distillation of horn, is susceptible of acquiring great thinness and volatility by repeated distillations, and is then called *the oil of Dippel.* *See that article.*

The horns of stags, and of other animals of that kind, are the most proper to furnish the animal oil to be rectified in the manner of Dippel; because they yield the largest quantity. These horns also differ from the horns of other animals in this, that they contain a larger quantity of the same kind of earth which is in bones; hence they seem to possess an intermediate nature betwixt horns and bones.

CCCLXXIII. HORN (HART'S) CALCINED *to* WHITENESS. The phlogiston of the coal of hart's-horn, although very difficultly combustible, may nevertheless be burnt with more ease than the coal of other horns, and with nearly the same facility as bones may. This coal, by being calcined with a long-continued and strong fire, is changed into a very white earth called hart's horn calcined to whiteness. This earth is employed in medicine as an absorbent. It is given in dysenteries and labor-pains which are supposed to be caused by acrid and ill-digested matters. Hart's-horn calcined to whiteness and levigated is the basis of Sydenham's *white decoction*, which is commonly prescribed in these diseases.

CCCLXXIV. HORN (HART'S) PREPARED PHILOSOPHICALLY. This name is given to hart's-horn deprived by water of almost all its gelatinous part; so that it becomes brittle; and when its outer part is taken off, it is thus rendered very white, and is applicable to the same uses as that which is calcined by fire.

CCCLXXV. HORN-BLEND. (*c*)

(*c*) HORN-BLEND is a black or green indurated bole or clay, consisting of scaly particles, which are distinguishable from those of mica, by being less shining, thicker, and rectangular. It is generally found amongst iron ores, and sometimes intermixed with mica, forming a compact stone.

CCCLXXVI. HORNSTEIN. (*d*)
CCCLXXVII. HYACINTH. (*e*)

(*d*) HORNSTEIN, *Petrosilex Wallerii.* This name is given by German authors to the siliceous stone called in England chertz. *See* CHERTZ.

(*e*) HYACINTH, or JACINTH, is a precious stone, polygonal, more or less transparent, of a yellowish red color, the ninth in degree of hardness from diamonds, and fusible by fire.

CCCLXXVIII.

I.

CCCLXXVIII. JACINTH. *See* HYACINTH.
CCCLXXIX. JALAP. (*f*).
CCCLXXX. JAPONIC EARTHS. (*g*).
CCCLXXXI. JASPER. (*h*).
CCCLXXXII. ICHTHYOCOLLA. *See* ISINGLASS.
CCCLXXXIII. JELLY. From many vegetables, mucous substances capable of forming kinds of jelly are obtained, but these are more frequently called *mucilages* and *gums*. The name *jelly* or *gelatinous matter* is particularly applicable to the mucous substance obtained from animals.

The bodies of most animals seem to be chiefly composed of gelatinous matter. For if we boil in water, flesh, bones, membranes, tendons, nerves, horns, skin, in a word, any of the several solid or soft parts which compose animal bodies, and if we evaporate sufficiently this water, the liquor by cooling will become a true jelly. If the evaporation be continued till the matter be dry, but with a heat incapable of decomposing this jelly, it forms at first a glue, and afterwards a horny substance more or less transparent, hard and solid.

(*f*) JALAP. From sixteen ounces of root of jalap, spirit of wine extracted five ounces, and four scruples of resinous matter; and from the residuum, water extracted two ounces and a half of gummy-matter. This root is observed to have a considerable power in promoting the spirituous fermentation of sweet vegetable juices, as of melasses. *Neuman.*

(*g*) JAPAN-EARTH. This name is improperly given to a gum-resin, obtained by inspissating the juice or decoction of the fruit of a certain palm-tree, which grows in the East Indies. It is almost entirely soluble, when pure, by water, or by spirit of wine. Its taste is at first bitterish and styptic, and is afterwards agreeably sweet. *Neuman.* The Indians are said to cut the fruit of this tree into small pieces, which they wrap in the leaves of the maritime plant *betel*, together with some quicklime, and to chew these balls, the taste and smell of which they find to be very agreeable.

(*h*) JASPER is an opake siliceous stone, of various colors, white, green, red, yellow, black, or variegated with spots or with veins of different colors. It differs from flints and chertz in being opake, in being more easily fusible by fire, in having a granulated texture, and in frequently composing large masses, or rocks; whereas flints and chertz are generally in form of nodules or lumps. From some jaspers, iron may be obtained. They are sufficiently hard and compact to receive and retain a fine polish.

When jaspers are spotted with specks of onyxes or agates, they are called *jasponyxes*.

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The blood, lymph, and ſeminal fluid of animals are ſcarcely any thing but pure gelatinous matter. Milk contains a large quantity of it. *See* Cheese. In a word, almoſt all animal liquors, excepting the excrementitious, ſuch as urine and ſweat, are nothing but kinds of watery jellies.

Hence we ought to conclude, that the gelatinous matter of animals is the true animal ſubſtance. It conſtitutes almoſt entirely the body of animals; it is that which nouriſhes, repairs, and reproduces them; it is in the animal kingdom, what mucilage is in the vegetable kingdom, from which it ſeems to be derived, and which it reſembles in many of its properties. *See* Gums *and* Mucilages.

This matter in its natural ſtate has ſcarcely any ſmell, or any acid or alkaline quality. Its taſte is ſweet and faint. When diluted with water, and by the help of other circumſtances neceſſary to fermentation, it eaſily ferments as ſoon as it is deprived of vital motion, and ſometimes even during the life of the animal to which it belongs. It occaſions ſeveral diſeaſes, and conſiderably deranges the animal economy. At firſt it tends ſlightly to the acid fermentation, as may be obſerved in milk, in blood, in fleſh, and broths; and then it paſſes very quickly to a compleat putrefaction, which reduces it to a very fetid liquid ſubſtance. *See* Fermentation *and* Putrefaction.

When it is very freſh, and expoſed to a degree of heat not exceeding that of boiling water, nothing riſes from it but its ſuperabundant phlegm, or water. By loſing this ſuperabundant water it becomes more and more gluey, and at length acquires nearly the conſiſtence of horn. In this ſtate, when it has ſuffered no other alteration than this kind of drying, it may be again diſſolved in water, and reſume its former liquid gelatinous ſtate.

Nevertheleſs, ſome gelatinous matters, ſuch as the whites of eggs, and the white part of the blood which is not watery, are coagulated and hardened by heat; and theſe, when once well dried, cannot be again rediſſolved in water, or at leaſt without great difficulty and particular management.

Acids and alkalis, the latter particularly, attack and diſſolve jelly, with great eaſe. The reſults of theſe combinations have not yet been ſufficiently examined.

Oily ſubſtances appear to have no action upon gelatinous matter. Neither can rectified ſpirit of wine diſſolve it. This ſpirit does not act upon it when it is dry, and only takes from it part of its water when it is and thus coagulates it. It then appears a precipitate compoſed of little white flocks. To this property which ſpirit of wine has of coagulating jelly, is with much probability attributed, the thickening the ſtuffing and breaking of the lymphatic veſſels, whence extravaſation and dropſy follow; in the principal diſeaſes of thoſe who drink too much of ſpirituous liquors.

When dry gelatinous matter is expoſed to a degree of heat ſuperior to that of boiling water, it ſwells, riſes into bubbles, emits an acrid, empyreumatic, fetid ume, and is with difficulty, and not without a very violent heat, inflammable.

If it be diſtilled in a retort with a graduated firſt a little phlegm is obtained; then volatile alkali, a thin penetrating oil, ſolid volatile alkali, and a empyreumatic oil, which becomes more and more thick, follow in the or are here ment In the retort a conſiderable quantity of that of coal remains, which cannot be burnt without great

great difficulty. From the ashes of this coal an exceeding small quantity of fixed alkali, and a little common salt may generally be obtained. These are exactly the same substances which may be obtained from all animal matters. As many things are common to jelly and to vegetable mucilage, *see the word* MUCILAGE.

CCCLXXXIV. JET.* (i).

CCCLXXXV. INDIGO. (k).

CCCLXXXVI. INFLAMMATION *of* OILS *by* NITROUS ACID. The vivid inflammation occasioned by mixing highly concentrated nitrous acid with most oils, is one of those surprizing phenomena, which excite the admiration even of people the most unintelligent, and least conversant in matters of chemistry and experimental philosophy. No wonder, therefore, that it has particularly excited the attention of chemists. Glauber, Borrichius, Tournefort, Homberg, Rouviere, Dippel, Hoffman, Geoffroy, and Mr. Rouelle, have particularly applied themselves to this matter. These chemists have successively found methods of inflaming different oils, and have published their processes in their writings.

Borrichius, a Danish chemist, had affirmed in the Copenhagen Transactions for the Year 1671, that oil of turpentine may be inflamed by mixing it with nitrous acid. But as in that time a highly concentrated nitrous acid was very rare, most of the chemists who attempted to repeat this experiment, did not succeed. Tournefort, in the year 1700, inflamed by this method the oil of sassafras. Homberg in the year 1701 says, in the Memoirs of the Academy, that he inflamed oil of turpentine by mixing it with nitrous acid; but he says

(i) JET, *Gagates, Succinum nigrum*, is a black bitumen, resembling fine black ebony wood, hard, light, compact, and smooth. It is very inflammable, and burns with a bituminous smell. By distillation it yields, 1. an acid liquor; 2. a thin black oil; 3. a thick black oil. By friction it becomes electrical, as amber does. *See* BITUMEN.

(k) INDIGO is a blue fecula, obtained from the American plant *anil* by means of fermentation, in the following manner. The herb is put into a vat and covered with water. In a few hours the liquor begins to ferment, becomes hot, throws up a froth, and acquires a blue or violet color. The liquor is then emptied into another vat by means of a cock inserted near the bottom of the first vat. In the second vat, the liquor is to be continually and strongly agitated by sticks and buckets annexed to sticks, by which means the blue coloring matter is made to unite together, or is disposed to separate from the liquor, and to subside. When the blue matter has subsided, the water is let off by cocks, and the sediment, when drained and dried in the air, is indigo.

Indigo may be almost entirely consumed by fire. With water it may be formed into a paste, diffusible through more water; but at last the coloring matter subsides. By means of fixed alkaline salt it becomes permanently diffusible in water. Woolen stuffs previously steeped in warm water, being dipped in the above liquor, are dyed of a green color, which is almost instantly, by exposure to air, changed to a fine blue. Volatile alkaline spirits extract yellowish or brownish red tinctures, and spirit of wine a reddish tincture, by digestion with indigo. Indigo gives no color to lime-water, or to water acidulated with vitriolic, nitrous, or marine acids. The concentrated vitriolic acid unites with indigo into a smooth paste, especially if the indigo be previously ground with powdered glass, or sand. By this method, the indigo is rendered soluble in boiling water along with the acid, so as to pass through a filter. This solution, when hot, is of a bright green color, and, when cold, becomes brown. The above experiments are mentioned by Dr. Lewis in a note to his translation of Neuman's Works.

that the oil must be thick. Rouviere, in the year 1706, inflamed the empyreumatic oil of guyac; and his experiment was much talked of, because it succeeded more easily than the others, because this inflammation is very vivid, and because it is attended by a surprizing circumstance; namely, that from amidst the flames arises a black, thin, spongy body, of a considerable height, which is, as we shall see, only the thickest part of the oil rarefied and burnt during the inflammation. This inflammation of oil of guyac was solely attended to, and was shewn to students in courses of chemistry and experimental philosophy; till Hoffman, a German chemist, and Geoffroy, a French chemist, having made many experiments on this matter, discovered at the same time, that smoking nitrous acid mixed with concentrated vitriolic acid, succeeded infinitely better for the inflammation of oils, and particularly of the oil of turpentine, which had been almost relinquished. Mr. Rouelle then resumed this subject, and published in the year 1747, a Memoir filled with many experiments, which shewed, that by nitrous acid may be inflamed all essential oils, including oil of turpentine, and even those sweet expressed oils which are capable of quickly thickening and drying, such as oils of nuts, linseed, hemp, provided that the acid be sufficiently concentrated. Lastly, the same chemist discovered that even the sweet oils least disposed to dry, that is, those called *fat oils*, may also be inflamed. But to make their inflammation succeed, the method mentioned by Hoffman and Geoffroy was necessary; that is to say, some concentrated vitriolic acid must be previously mixed with the nitrous acid. As these last mentioned oils are of all oils the least inflammable, we have reason to believe that every oil may be inflamed by a mixture of these two acids.

Mr. Rouelle further remarks, in the above quoted Memoir, that flame is more certainly produced in all these experiments, when the nitrous acid is poured on at intervals, and when it is applied to that part of the oil which the portions of acid first poured on had thickened, heated, and dried. The inflammation of oils by acids is now become an experiment easily performed. The following circumstances are remarked to be peculiar to the inflammation of the several kinds of oil.

All essential oils, and even the sweet drying oils, may be inflamed by the nitrous acid alone, provided that the vessel in which the inflammation is to be made be of a convenient size and form, that the nitrous acid be sufficiently concentrated, and that a sufficient quantity of acid and oil be employed. The vessel ought to be sufficiently wide-mouthed; and the nitrous acid, for greater certainty, ought to be so concentrated that a phial capable of containing exactly an ounce of pure water, shall be capable of containing one ounce four gros and two scruples of this acid. Lastly, an ounce of this acid, and as much of the oil to be inflamed, ought to be employed, although less quantities may succeed, but less certainly. The oil is first put into the vessel in which the inflammation is intended to be. Then the vessel containing the nitrous acid is to be tied to one end of a rod, that the operator may not be hurt by the part of the mixture which is generally thrown out of the vessel, and sometimes at a considerable distance. One half or two-thirds of the acid is poured at once. A considerable ebullition is excited by the reaction of these two liquors. The oil becomes black, thick, and sometimes inflames. If it does not inflame

within

within four or five seconds, more nitrous acid must be poured upon the part which appears thickest and dryest, and then the mixture never fails to be inflamed.

The oils of almonds, olives, rapes, and other fat oils, have not been hitherto inflamed by the nitrous acid alone. But their inflammation is effected, as Mr. Rouelle practises, by mixing with them first equal quantities of the concentrated vitriolic and nitrous acids, which occasion less quick and violent ebullition than in the preceding instances; but when this ebullition is at its height, some pure nitrous acid must be poured on the thickest part of the mixture. Then the inflammation generally happens, but is less strong than when any other kind of oil is used.

Although these phenomena be surprizing, their theory is easy. All oils contain phlogiston as a constituent part. Nitrous acid also contains phlogiston. Hence we may understand the cause of the powerful action of these two substances upon each other. The heat resulting from their reaction, is equal to that of ignition; and hence the oil and even the nitrous acid being capable of inflammation, must consequently be inflamed.

The reaction becomes more strong, and the inflammation more certain, when the nitrous acid is applied to the part of the oil which has already been thickened and dried, either by the nitrous acid alone, or by that acid mixed with vitriolic acid. But ought this portion of thickened and dephlegmated oil to be considered as a pure coal? And ought the action of the disengaged nitrous acid upon this thickened oil, to be compared to the action of nitre detonating with coal? We cannot be easily persuaded of this, when we consider that nitrous acid, however much concentrated, when not retained by some base, has no action upon any kind of coal, even when heated as much as possible. *See* DETONATION *of* NITRE.

The effect produced by the addition of the vitriolic acid, may be explained in the following manner. This acid does much promote these inflammations; since, on the one hand, it makes them succeed more certainly, and with less doses than can be done with the nitrous acid alone; and on the other hand, some oils have never hitherto been made capable of inflammation without it. But although this acid acts powerfully upon oils, it cannot singly inflame any of them. Mr. Rouelle considering, that as the vitriolic acid is essentially stronger, and has a greater affinity to water than nitrous acid, believes that it renders the nitrous acid more capable of inflaming oils by dephlegmating it. Probably the vitriolic acid may from this cause facilitate the inflammation of oils; but has it not also as great an affinity with the water contained in the oils, as with that contained in the nitrous acid? and may not, consequently, its power of facilitating these inflammations proceed from the dephlegmation of the oils, as well as of the nitrous acid?

CCCLXXXVII. INFUSION. Infusion, taken in its most general sense, consists in placing compound bodies in a liquor intended to be impregnated with some of their principles, either without heat, or with a heat less than that of the boiling liquor.

From this definition we may see that infusion is one of the principal operations of the analysis by menstruums, in the same manner as decoction is, of which infusion may be considered as the first degree.

Infusion

Infusion may be made in watery, spirituous, oily, acid, or alkaline liquors, according to the nature of the matters to be infused, and of the principles intended to be extracted. It is nevertheless practised upon vegetable matters only, and almost always for the preparation of remedies which are also called *infusions*.

Aromatic plants and other odoriferous vegetable matters are generally infused when their odoriferous principle is to be preserved, in which their virtue consists; and which is at the same time so volatile as to be dissipated and lost by the heat of ebullition. To preserve still better these volatile principles, the smallest heat requisite for the extraction ought to be employed; and these infusions ought to be made in matrasses or other vessels, which may be exactly closed.

The principles extracted by infusion are different according to the menstruum employed.

Pure water may be impregnated with the odoriferous principle, or spiritus rector, with saline, saponaceous, mucilaginous, extractive principles. Spirit of wine dissolves the spiritus rector, the essential oils, those resinous matters the base of which is an oil of the nature of essential oils, and greatest part of the saponaceous extractive matter. Those infusions made by spirit of wine are particularly called *tinctures*, especially in pharmacy. Oils dissolve the spiritus rector, and any oily matter. Acids and alkalis dissolve the earthy substances of vegetables, and almost all their other principles: but they disguise them, alter them, and change considerably their virtues by the combination. They are therefore not much used for these kinds of extractions. *See* ANALYSIS, DECOCTION, EXTRACTS.

CCCLXXXVIII. INK. Ink is a liquor, generally black, used for writing. Nevertheless some inks are of other colors.

The basis of black ink is an infusion of galls, and of martial vitriol, known to druggists by the name of green copperas; both which are mixed together, and to them is added some gum-arabic. The following receipt makes good ink: In four pints of common water or beer let a pound of bruised galls be infused twenty-four hours without boiling; to this add six ounces of gum-arabic; and when the gum is dissolved, six ounces of green vitriol, which will soon give it the black color: the liquor is then to be strained through a hair sieve.

Galls and all vegetable astringents have the property of separating iron, when it is united, either with vitriolic acid, or with any other acid; and the precipitate thus formed is black. The blackness of these precipitates is caused by a certain quantity of oily matter which they receive from the vegetable substances.

In the operation of making ink, something passes analogous to the precipitation of iron into Prussian blue, by means of a phlogisticated alkali. Some chemists having even remarked that ink diluted with much water has a color approaching to blue, have considered the martial precipitate of ink as a Prussian blue, the color of which is so intense as to seem black when diluted in a small quantity of water, because a very deep blue has actually the appearance of a black: but this opinion does not correspond with the properties of ink or of Prussian blue. Iron precipitated in these two methods is essentially different; and the difference proceeds from the different natures of the two inflammable

matters

matters with which the iron unites itſelf in theſe two caſes. The inflammable matter which unites with iron in the preparation of ink is in an oily ſtate; and that in the preparation of Pruſſian blue is not in that ſtate. *See* BLUE (PRUSSIAN). Accordingly the precipitate of iron in ink is eaſily ſoluble by all acids; but the precipitate of Pruſſian blue is not. If a ſufficient quantity of ſpirit of nitre, or any other ſtrong acid, be mixed with ink, its color will diſappear, and the blackeſt ink will thus be rendered clear and tranſparent as water. Its blackneſs and opacity may be again reſtored to it by adding to the ink thus diſcolored a ſufficient quantity of alkali to ſaturate all the acid which had diſſolved the martial precipitate; by which means this precipitate reſumes its former appearance. Thus the black color of ink may be made to diſappear and appear again as often as we pleaſe, by mixing with it alternately ſome acid and ſome alkali: but this change of color cannot be produced upon the Pruſſian blue. By adding any quantity of an acid to the water in which Pruſſian blue is ſuſpended, its color, ſo far from being altered, becomes only the more beautiful by that addition.

The color of Pruſſian blue may be indeed made to appear and diſappear at pleaſure by one method: but this method is preciſely the reverſe of that uſed to produce thoſe effects upon ink. By mixing much alkali with Pruſſian blue, its color is deſtroyed; and by ſaturating this alkali with an acid, the color is reſtored. This conſtitutes a very ſenſible difference betwixt theſe two martial precipitates.

Inks of all colors may be made by uſing a ſtrong decoction of the ingredients uſed for dying, mixed with a little alum and gum-arabic. For example, a ſtrong decoction of braſil wood with as much alum as it can diſſolve, and a little gum-arabic to give it body and ſome conſiſtence, forms a beautiful red ink. (*l*)

(*l*) As the duration of records and other valuable writings depends much on the goodneſs of the ink employed, Dr. Lewis has thought this ſubject worthy of his attention. The chief imperfection of common inks is, that they decay in time, and at laſt the writing becomes inviſible. From experiments made by that author, he infers that the decay of inks is chiefly owing to a deficiency of galls; that the galls are the moſt periſhable ingredient, the quantity of theſe, which gives the greateſt blackneſs at firſt, (which is about equal parts with the vitriol) being inſufficient to maintain the color; that for a durable ink, the quantity of galls cannot be much leſs than three times that of the vitriol; that it cannot be much greater without leſſening the blackneſs of the ink; that by diminiſhing the quantity of water, the ink was rendered blacker and more durable; that diſtilled water, rain water, and hard ſpring water, had the ſame effects; that white wine produced a deeper black color than water; that the color produced by vinegar was deeper than that by wine; that proof ſpirit extracted only a reddiſh-brown tinge; that the laſt mentioned tincture ſunk into, and ſpread upon, the paper; and hence the impropriety of adding ſpirit of wine to ink, as is frequently directed, to prevent mouldineſs or freezing; that other aſtringents, as oak bark, biſtort, ſloe-bark, &c. were not ſo effectual as galls, nor gave ſo good a black, the color produced by moſt of theſe, excepting oak-bark, being greeniſh; that the juice of ſloes did not produce a black color with martial vitriol; but that, nevertheleſs, the writing made with it became black, and was found to be more durable than common ink; that inks made with ſaturated ſolutions of iron in nitrous, marine, acetous, acids, in tartar, or in lemon juice, were much inferior to the ink made with martial vitriol; that the color of ink was depraved by adding quicklime, which was done with an intention of deſtroying any ſuperabundant acid which might be ſuppoſed to be the cauſe of the loſs of the color of ink; that the beſt method of preventing the effects of this ſuperabundant acid is probably by adding pieces of iron to engage it;

CCCLXXXIX. INKS (SYMPATHETIC). Chemiftry furnifhes many methods of making the inks called fympathetic. Thefe inks are colorlefs liquors, with which an invifible writing is made, but which becomes very fenfible when we pleafe, by certain treatment appropriated to the particular kind of fympathetic ink employed.

As ordinary ink is made black by a mixture of two liquors which are not, or but very little colored, it may become a fympathetic ink by feveral methods.

If green vitriol be diffolved in water, and a little acid be added, to prevent the yellowifh martial precipitate, which is always formed when there is not fuperabundant acid, with this folution invifible characters may be written, which may be rendered very black, by being moiftened with a ftrong infufion of galls.

If the blacknefs of ordinary ink be deftroyed by a fufficient quantity of nitrous acid, the writing made by it will remain invifible, till it be moiftened by liquid fixed alkali.

Characters traced with the acid folution of green vitriol above-mentioned will become of a fine blue color, if they be moiftened with the phlogifticated alkaline liquor ufed in the preparation of Pruffian blue; and characters traced with this laft mentioned liquor, which are abfolutely invifible, may be rendered of a fine blue color by being moiftened with a folution of green vitriol. The theory of thefe inks may be feen under the articles INK, *and* BLUE (PRUSSIAN).

Pure vitriolic acid, weakened by fo much water that it fhall not make too ftrong an impreffion upon paper, becomes a fympathetic ink, the characters written with which are invifible; but may be rendered fenfible by heating the paper on which they are traced. This effect is occafioned by the heat concentrating the acid, and rendering it capable of burning and blackening the paper. But

and that this conjecture was confirmed by an inftance the author had heard, of the great durability of the color of an ink in which pieces of iron had been long immerfed; and laftly, that a decoction of logwood ufed inftead of water, fenfibly improved both the beauty and deepnefs of the black, without difpofing it to fade. The fame author obferves, that the addition of gum-arabic is not only ufeful, by keeping the coloring matter fufpended in the fluid, but alfo by preventing the ink from fpreading, by which means a greater quantity of it is collected on each ftroke of the pen. Sugar, which is fometimes added to inks, was found to be much lefs ufeful than gums, and to have the inconvenience of preventing the drying of the ink. The color of ink is found to be greatly injured, by keeping the ink in veffels made of copper, or of lead, and probably of any other metal, excepting iron, which the vitriolic acid can diffolve. The foregoing experiments point out for the beft proportions of the ingredients for ink; one part of green vitriol, one part of powdered logwood, and three parts of powdered galls. The beft menftruum appears to be vinegar or white wine, tho', for common ufe, water is fufficient. If the ink be required to be of a full color, a quart, or, at moft, three pints, of liquor may be allowed to three ounces of galls, and to one ounce of each of the other two ingredients. Half an ounce of gum may be added to each pint of the liquor. The ingredients may be all put together at once in a convenient veffel, and well fhaken four or five times each day. In ten or twelve days the ink will be fit for ufe, though it will improve by remaining longer on the ingredients: or it may be made more expeditioufly, by adding the gum and vitriol to a decoction of galls and logwood in the menftruum. To the ink, after it has been feparated from the feculencies, fome coarfe powder of galls, from which the fine duft has been fifted, together with one or two pieces of iron, may be added, by which its durability will be fecured.

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this ink is not convenient for uſe; becauſe the vitriolic acid, although weakened by water, always injures the paper, and at length deſtroys it.

Amongſt the moſt famous ſympathetic inks is that made with the ſolution of biſmuth in nitrous acid. The inviſible characters written with this ink may be rendered ſenſibly black without being moiſtened or heated but by being expoſed to the contact of phlogiſton reduced into vapors; becauſe this phlogiſton revives the earth of biſmuth, which is partly calcined by the nitrous acid, and even applies itſelf, ſuperabundantly, to that metallic earth, which it blackens ſo much more, as it is in greater quantity.

The phlogiſtic vapors exhaling from liver of ſulphur are the fitteſt for producing this effect upon the ſolution of biſmuth. The authors who firſt deſcribed this ſympathetic ink, required that a ſolution of the ſcoria of regulus of antimony, or of a mixture of quicklime and orpiment, ſhould be employed: but as the former of theſe ſubſtances is an antimoniated liver of ſulphur, and as the latter is an earthy liver of ſulphur, mixed with arſenic, we may perceive that they produce their effects only as being livers of ſulphur. The ordinary liver of ſulphur is found to ſucceed equally well.

When therefore characters written with the ſympathetic ink of biſmuth are required to appear, expoſure to the vapors of liver of ſulphur is ſufficient for that purpoſe; and theſe vapors are ſaid to be capable of producing their effect acroſs a quire of paper, or even a ſtone-wall. This does not appear impoſſible, but it muſt require a long time. We are certain, that the white precipitate of biſmuth, nitrous cryſtals of biſmuth, or of lead, although well covered with paper, become blackened on their ſurfaces by remaining in laboratories where phlogiſtic vapors float, particularly the vapors of liver of ſulphur.

We may eaſily perceive that the writing made by this ink of biſmuth may be more readily made to appear by being moiſtened with a ſolution of liver of ſulphur. (*m*)

The moſt modern ſympathetic ink, and, at the ſame time, one of the moſt curious, is that made with a ſolution of the regulus or calx of cobalt in aqua regia. The proceſs of this ink has been publiſhed in the Memoirs of the Academy of Sciences by Mr. Hellot.

This proceſs was very troubleſome; becauſe he directed that cobalt itſelf ſhould be employed, which muſt be firſt roaſted; then diſſolved in nitrous acid; and, laſtly, to the ſolution ſome ſea-ſalt muſt be added; and alſo becauſe good cobalt is very ſcarce. But this ink may be eaſily made. For this purpoſe, let the

(*n*) Inſtead of the ſolution of biſmuth in nitrous acid, a ſolution of ſugar of lead in water may be employed for the ſame purpoſe; and the writing made with this liquor is rendered black by vapors of liver of ſulphur, or ſtill more effectually by the ſolution of liver of ſulphur in water. But as theſe chemical liquors may require more management than can be conveniently applied, or perhaps comprehended by ſome lovers, and other perſons engaged in myſterious correſpondencies; Ovid, that admirable inſtructor, has recommended a more familiar and domeſtic method of communicating tender ſentiments without danger of diſcovery from fathers or huſbands. This method conſiſts in writing with milk, which, by being held near a fire, is rendered viſible. The juice of lemons has alſo been uſed with great ſucceſs, for the ſame purpoſes, and in the ſame manner. The color given to theſe two laſt mentioned liquors proceeds from a beginning decompoſition of their oily and mucilaginous particles by means of heat. Not only theſe liquors, but all the ſympathetic inks, mentioned by authors, may be rendered more or leſs viſible, by application of heat.

zaffre be taken which is commonly sold by druggists, from which, by digestion in aqua regia, may be extracted all that this acid is capable of dissolving: this soluble part of zaffre is the calx of cobalt, which is used for giving a blue color to glass. This solution is then to be diluted with a little common water, to prevent it from making too strong an impression upon paper. Characters written with this diluted solution are invisible when cold, and become of a fine greenish-blue when heated; and have this singular property, that after they have been rendered visible by heat, they again disappear when exposed to cold, and may thus be made to appear and disappear alternately, by alternate applications of heat and cold: but care must be taken to heat the paper no more than is just sufficient to make the writing appear; for when it is heated too much, the writing will not again disappear by exposure to cold.

This ink may be applied to the drawing of landscapes, in which the earth and trees destitute of verdure, being drawn with common ink, give a prospect of winter; and which may be made to assume the appearance of spring, by exposure to a gentle heat, which covers the trees with leaves, and the earth with grass, by rendering visible those parts of the landscapes which are drawn with this sympathetic ink. This idea has been executed upon fire-screens by an industrious artist (*n*)

By reflecting a little upon the properties of chemical agents, and on the phenomena of many operations, we may perceive that many new sympathetic inks with peculiar properties may be discovered.

CCCXC. INSTRUMENTS (CHEMICAL). The instruments employed in chemical operations are very numerous, and are described under their several articles. They are also enumerated in a general manner under the article LABORATORY.

CCCXCI. INTERMEDIUM, *or* INTERMEDIATE SUBSTANCE. Those substances are called *intermediate* by means of which other substances incapable of uniting together alone, may be united. For example, saline, acid, or alkaline substances, by means of which oils are reduced to a saponaceous state, and are thereby rendered miscible with water, are the intermediate substances of this union of oil with water; because, without these saline substances, oil and water cannot be united, or even well mixed.

Those matters are also called intermediate, which are employed to disunite others, which cannot be otherwise disunited. In this sense vitriolic acid is an intermediate substance, by which nitrous or marine acids may be separated from any alkaline salt, with which they happen to be united.

CCCXCII. IPECACOANHA. (*o*)

CCCXCIII. IRON. Iron, called also *Mars*, is a metal of a white, livid, greyish color. It is the hardest of all metals, the most elastic, and, ex-

(*n*) We may observe, that a solution of regulus of cobalt, or of zaffre, in spirit of nitre, acquires a reddish color by application of heat. Hence, some variety of color might be given to the landscapes proposed in the text. Thus while the green solution of this semi-metal in aqua regia represented the leaves, the red solution might represent the fruits and flowers.

(*o*) IPECACOANHA. From sixteen ounces of good ipecacoanha, three ounces of resinous matter were extracted by means of spirit of wine; and from the same quantity, by means of water, five ounces of gummy matter were extracted. *Neuman.*

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cepting platina, the moſt difficult to be fuſed. This metal has, next to gold, the greateſt tenacity of parts; an iron wire, the diameter of which is a tenth part of an inch, being capable of ſuſtaining 450 pounds, without being broken.

Next to tin, iron is the lighteſt of the metals. It loſes when immerſed in water betwixt a ſeventh and an eighth part of its weight. A cubic foot of forged iron weighs 580 pounds.

Very pure iron is ſufficiently ductile to be drawn into wire as fine as horſe-hair. But theſe properties of iron are ſubject to vary much in their degrees, according to the different kinds of iron. This difference proceeds from a quantity, ſometimes greater and at other times leſs, of an earth contained in iron, which is unmetallic, or at leaſt which is not metalliſed, from the great difficulty of fuſing perfectly its ore. *See* ORES *of* IRON *and* SMELTING *of* ORES.

Iron is the only known ſubſtance which is attracted by magnets, and capable of becoming itſelf a magnet, ſo as to attract other iron. By this property it may be diſcovered in mixtures where by other methods it could ſcarcely be perceived, and may be even ſeparated, when it is only interpoſed betwixt other bodies, and not adherent to them. It preſerves this property, although it be allayed with ſome other metals. Henkel ſays, in his Pyritologia, that iron allayed with two parts of copper is ſtill magnetical. (*p*)

Iron is a very deſtructible metal. Its ſurface is quickly converted by the combined action of air and water into a ruſt or yellow calx, deprived of all its phlogiſton. This calx is only an earth deprived of metallic properties, and which cannot recover theſe properties, without being again combined with its inflammable principle. The deſtruction of iron expoſed to a moiſt air by ruſt, is univerſally known. The ruſt of iron, and the other calxes of this metal, are called *ſaffron of Mars*, *crocus martis* *See* SAFFRON *of* MARS.

Water alone, without the help of air, ſeems to be capable of acting upon iron in ſome meaſure, without depriving it indeed of its inflammable principle: but it divides and conſiderably attenuates it; which ſeems to ſhew that this metal contains ſome ſaline parts. *See* ETHIOPS MARTIAL.

Iron is not fuſible by the heat of ordinary furnaces; but it is eaſily burnt and calcined, by which it is changed into an earthy matter more or leſs reddiſh or blackiſh, called *aſtringent ſaffron of Mars*. *See that word*. This ſaffron of Mars is nothing but the proper earth of iron deprived of the greateſt part of its phlogiſton by calcination.

Iron heated as much as is poſſible, that is, till it becomes of a ſhining white color, and juſt beginning to fuſe, has the appearance of a combuſtible body, penetrated by a vivid and bright flame: and indeed the inflammable principle of this metal heated to that point, really burns in a ſenſible manner. A number of vivid and ſhining ſparks ſhoot out from it, and burn with a kind of decrepitation. I have expoſed iron to the focus of a large burning glaſs, where it quickly fuſed and boiled, and emitted an ardent fume, the

(*p*) A greatly ſmaller proportion of iron in an allay of copper with that metal, retains its magnetical quality. Gellert affirms, that the magnetical quality of iron is deſtroyed by allaying it with regulus of antimony. He obſerves, that the ſurface of his allay was covered with ſpots like ruſt; which circumſtance induces a ſuſpicion that his iron might have been injured by ſulphur, ſome of which is frequently retained by regulus of antimony.

lower part of which was a true flame. At length it was changed into a blackish vitrified scoria. The sparks struck from iron by flints are nothing but bits of iron heated by violent collision, and when collected upon paper, and viewed by means of a microscope, appear to be like scoria of iron, or slag. (*q*).

All the acids dissolve iron, and in their solutions exhibit particular phenomena.

If filings of iron be put into a matrass, and a sufficient quantity of vitriolic acid added to dissolve it, the solution will be made with heat and effervescence. The vitriolic acid, when it dissolves the iron in this manner, takes from it much of its inflammable principle: for the vapors which exhale from this solution have not only a strong smell of volatile sulphureous acid, but they are so impregnated with phlogiston, that they are very inflammable. An experiment may be made to render this truth sensible by sight. Let the mouth of the matrass be stopt by a finger during thirty or forty seconds, and a lighted candle be brought very near the mouth when it is to be unstopped; a flame will then immediately appear within the matrass, and at the same time a strong explosion will happen. This explosion would break the matrass, if the quantity of filings of iron was considerable, for instance eight or nine ounces, and if the neck of the matrass was straight. This inflammation and this explosion may be frequently repeated, when the solution is made with some activity; and if the matrass be left unstopt after the explosion, and the vapor be kindled, it continues to burn at the mouth of this vessel with a blue tranquil flame, while the solution continues. *See* AIR (FIXABLE INFLAMMABLE), *and* DAMPS.

From the solution of iron by vitriolic acid, a vitriolic salt with metallic basis is formed, which by evaporation and cooling is coagulated into green rhomboidal crystals. This salt is called *martial vitriol*, *green vitriol*, or *green copperas*. See its properties at the article VITRIOL (MARTIAL).

Nitrous acid dissolves iron most actively and violently. This acid cannot scarcely be saturated with iron; because when it has dissolved a large quantity of iron, and seems to be so saturated, that some of the metal is deposited under

(*q*) Iron is a combustible substance, as appears from the great waste or loss of quantity observable in iron exposed to a red, but especially to a white heat. This combustion is maintained and excited, like that of all other combustible substances, by contact of air. Dr. Hook says, that having heated a bar of iron to that degree called white heat, he placed it upon an anvil, and blowed air upon it by means of bellows, by which it burnt brighter and hotter. The sparks produced by the collision of steel with flint, appear to be globular particles of iron which have been fused, and imperfectly scorified or vitrified. They are kindled by the heat produced by the collision; but their vivid light, and their fusion or vitrification, are the effects of a combustion continued in these particles during their passage through the air; and these effects are so great in so short a time, because the quantity of surface of these minute particles of iron, and consequently the quantity of air applied to excite the combustion, is so great in proportion to the quantity of matter. This opinion, that the ignition, light, and fusion of the sparks are occasioned by the heat, excited by the combustion of their own inflammable matter, and not merely by the heat communicated by the collision, is confirmed by an experiment made and related by Mr. Hawksbee; from which we find that these sparks struck by collision are not visible, that is, they are not ignited, and do not deflagrate, in an exhausted receiver; the air being necessary to maintain and excite their deflagration and combustion.

form of martial ſaffron; if more iron be then added, it will be diſſolved, while ſome of that which was before diſſolved will be precipitated.

The cauſe of this phenomenon is, that the nitrous acid takes from the iron much of its phlogiſton during the ſolution, and alſo that iron has ſo much leſs adheſion to nitrous acid, as it is more deprived of phlogiſton. This being eſtabliſhed, we may perceive, that when iron containing its due quantity of phlogiſton is added to nitrous acid ſaturated with a half dephlogiſticated iron, this acid, greedy of the inflammable principle, quits the latter metal, and diſſolves the former.

The vapors of nitrous acid which diſſolves iron are always very red, of a nauſeous ſmell, more diſagreeable, and apparently more volatile, than thoſe of the uncombined acid. This obſervation may be applied to all ſolutions with nitrous acid of thoſe metallic ſubſtances, which are capable of loſing their inflammable principle. Theſe qualities of nitrous acid proceed from the ſuperabundant quantity of phlogiſton, which it imbibes in every ſolution. Experiments might be made to try whether the vapors which exhale from this ſolution, and from ſolutions of ſeveral other metallic ſubſtances abounding in phlogiſton, are inflammable, like thoſe which exhale from a ſolution of iron in vitriolic acid. But theſe experiments ought to be made cautiouſly, leſt exploſions ſhould happen.

Marine acid alſo diſſolves iron with eaſe, and even with activity; but it does not take from the metal its inflammable principle ſo efficaciouſly as nitrous acid does, and even as vitriolic acid, although it does produce ſome change upon it in this reſpect. A great chemiſt affirms, that marine acid treated with iron acquires the properties of nitrous acid. (g)

Aqua regia diſſolves iron with much impetuoſity, and preſents phenomena partaking of thoſe of the ſolutions of this metal in the nitrous, and in the marine acids ſeparately.

Iron forms with the nitrous and marine acids, ſeparately or conjointly, ſalts with metallic baſes, of a deliqueſcent nature.

When ſolutions of iron with any of the mineral acids are made with much ſuperabundant acid, their color is more or leſs green, and they remain clear without making any depoſition: but when the acid is ſaturated with metal, the color of the ſolution is more or leſs yellow or reddiſh, and a certain quantity of yellow ferruginous earth called *ockre* or *ſaffron of Mars* is depoſited. Theſe differences proceed from this cauſe, that iron requires ſo much more acid to keep it diſſolved, as it is more deprived of its phlogiſton.

Laſtly, when ſolutions of iron, not too acid, and particularly when diluted with water, are heated, they become turbid, and immediately depoſite a quantity of ochre, which they would not have depoſited but in a long time, if they had not been heated.

Ochres, or ſaffrons of Mars, which are depoſited from ſolutions of iron, are not ſo ſoluble as iron: they require a much greater quantity of acid, or cannot be again diſſolved, particularly by nitrous acid, but by peculiar management.

Vegetable acids alſo diſſolve iron. The acid of tartar forms with this metal a ſort of vegetable metallic ſalt, or of ſoluble tartar, which is deliqueſ-

(g) This great chemiſt is Stahl. The experiment has not been confirmed by other chemiſts.

cent; and is called TINCTURE (TARTARISED) *of* MARS; which *see*. Martial or vulnerary balls are made by mixing acid of tartar with filings of iron; which being diſſolved in water furniſh a true ſoluble martial tartar, or tartariſed tincture of Mars. *See* BALLS (MARTIAL).

Iron, like other metals, diſſolved in any acid, may be precipitated by abſorbent earths and alkaline ſalts. But this metal, like all others, preſents, when precipitated by fixed alkalis, different phenomena, according to the particular ſtate of the alkali.

If the alkali employed to precipitate iron is as much dephlogiſticated as it can be, the ferruginous precipitate is of the color of ruſt. If this alkali contains any ſuperabundant phlogiſton, a part of this phlogiſton will be tranſferred to the iron during its precipitation, and will give it an olive color, more or leſs deep. This precipitate may be eaſily and inſtantaneouſly rediſſolved by pouring upon it a quantity of acid ſufficient to ſaturate the alkali, and to diſſolve the precipitate. This precipitate, when dried with proper precaution, (*ſee* ETHIOPS MINERAL) forms an excellent ſaffron of Mars for the uſe of medicine. Laſtly, if an alkali much impregnated, or ſtill better, if ſaturated with phlogiſton, be added, the precipitate will be of a blue color, and will form what is called *Pruſſian blue*. *See* BLUE (PRUSSIAN).

Alkalis act upon iron as upon all other metals, and are even capable of diſſolving it perfectly, when they can ſeize it ſufficiently divided, as Stahl has diſcovered. For this purpoſe a ſolution of iron by nitrous acid is to be poured into good liquid alkali. Immediately afterwards a red precipitate appears, which, upon agitating the alkaline liquor, inſtantly diſſolves, and communicates to the liquor its color. By this method a conſiderable quantity of iron may be diſſolved by an alkali. When this ſolution contains much iron, it is called *martial alkaline tincture of Stahl*. This operation cannot ſucceed but in certain circumſtances. Theſe circumſtances will be mentioned under the article TINCTURE (MARTIAL ALKALINE) *of* STAHL.

When this tincture is well impregnated with iron, a part of the metal is depoſited in form of a very fine yellow brick colored ſaffron of Mars; and at the ſame time the tincture loſes much of its color. All the iron may be quickly ſeparated from it under the ſame form, by ſaturating this alkali with any acid. This ferruginous precipitate is called *Stahl's ſaffron of Mars*. It is rendered ſufficiently ſoluble in acids by the phlogiſton transferred to it from the alkali. *See* SAFFRON *of* MARS.

Iron precipitates metals diſſolved in acids; and theſe precipitates have their metallic form and brilliancy, as all metallic precipitates, which have been ſeparated from the acids of their ſolutions by other metals, have. But iron may be ſeparated from acids by zinc, and by ſome other ſubſtances. *See* PRECIPITATION *and* PRECIPITATE. All vegetable aſtringent ſubſtances, as galls, pomegranate rind, &c. form inks, or black precipitates, with any ſolutions of iron. *See* INK.

Iron has a greater affinity than any other metal with ſulphur: hence it may be employed to ſeparate moſt metals from ſulphur, by fuſion; and ſulphur thus united with iron, conſiderably augments its fuſibility. *See* ESSAYS *of* ORES, *and* REGULUS (MARTIAL) *of* ANTIMONY.

If

If a bar of iron be heated till it becomes white, and a roll of ſulphur be applied to one of its extremities thus heated, the ſulphur, uniting with the iron, makes it fuſe ſo as to run down in red-hot drops. This experiment ought to be made over an earthen pan filled with water, to receive the melted iron and ſulphur, while they flow down copiouſly, that they may be extinguiſhed as faſt as they fall down, and that their diſſipation may be prevented. In the earthen pan, after this operation, are found ſome parts of pure ſulphur, which had melted without being combined with iron, and which are ſoftened (*ſee* SULPHUR); and other pieces compoſed of iron combined with ſulphur, and which had been fuſed together. Theſe latter pieces are brittle. They are iron artificially mineraliſed, or brought into a pyritous ſtate by ſulphur. *See* PYRITES.

Sulphur and iron act ſo ſtrongly upon each other, that they can mutually diſſolve each other even in the humid way. If five or ſix pounds of filings of iron be mixed with as much powdered ſulphur, and the mixture be moiſtened with a ſufficient quantity of water to form a paſte, this mixture will in a certain time ſwell, become hot, melt, emit vapors, and even take fire. This is an experiment of Mr. Lemery the elder. The reſiduum of this operation furniſhes martial vitriol, which has been produced by a tranſpoſition of acid from the ſulphur to the iron. Here the ſame things happen as in the decompoſition, effervescence, and inflammation of ferruginous pyrites. This union of the acid of vitriol with iron, and the formation of martial vitriol, may be much accelerated by heating and burning the ſulphur, immediately after the mixture. *See* PYRITES, SMELTING *of* ORES, *and* VITRIOL.

As the phlogiſton of iron is copious, and not much engaged, the filings of this metal when heated are capable of detonating with nitre, vividly and briſkly. Hence they are ſaid to be uſed by the Chineſe in their fire-works.

After this detonation, iron is reduced to a reddiſh calx, called *Zwelfer's Saffron of Mars.* *See* SAFFRON *of* MARS.

In whatever manner iron be treated and calcined, the calxes, the ochres, the ruſts, and the precipitates of this metal, are always colored; and the colors of ferruginous earth, in theſe different ſtates, are from the yellow pale of ruſt to a red brown or blackiſh brown. Hence we are induced to believe that martial earth is never entirely deprived of phlogiſton. This is alſo probably the cauſe that all theſe preparations of iron are eaſily ſuſceptible of reſuming phlogiſton, and even in the humid way; for generally metallic calxes reſume phlogiſton ſo much more eaſily, as they have been leſs perfectly deprived of it.

Theſe colors retained by calxes of iron render them fit to be uſed in painting, not only with oil, but alſo to tinge glaſs. Hence they are ſucceſsfully employed for coloring glaſſes or artificial precious ſtones, and for painting different ſhades of red upon pottery, enamel, and porcelain.

Iron may be allayed with all metals excepting lead and mercury, with which it has not yet been rendered capable of uniting. *See* ALLAY and TINNING.

Laſtly, one of the moſt intereſting properties of iron is, that it is capable of being combined either by fuſion or by cementation with a more abundant quantity of phlogiſton; of being converted thereby into a more perfect iron called *ſteel*, which is capable of acquiring by ſudden cooling or tempering a very

great hardneſs, which renders it very uſeful for numberleſs neceſſary purpoſes. *See* STEEL.

The affinities of iron are, according to Mr. Geoffroy's table, in the following order: Regulus of antimony, ſilver, copper, and lead. Theſe three laſt are placed ſo as to mark an equal degree of affinity with iron. But we muſt obſerve, that lead ought not to have been placed there, becauſe it has no affinity with iron: but as iron united with ſilver may be inſtantly ſeparated from the ſilver by addition of lead, which unites with the ſilver, and obliges the iron to float upon the ſurface of this new mixture; Mr. Geoffroy ſeems to have meant to have ſhewn this effect in this column of his table of affinities, which however is not very accurate: for this experiment only ſhews, that ſilver quits iron to unite with lead. Mr. Gellert's table of ſolutions gives for the affinities of iron, gold, ſilver, and copper. Lead and mercury might be placed at the bottom of the column, where ſubſtances are mentioned which cannot be united with that which is placed at the head of the column. (*s*)

The uſes of iron are ſo well known, and ſo numerous, that they need not be enumerated. We ſhall only obſerve, that no metal is ſo uſeful. It is, as it were, the ſoul of the arts, and is neceſſary for the exiſtence of them all.

This metal furniſhes alſo very efficacious remedies, the virtues of which are well eſtabliſhed by practice. This is almoſt the only metal which is not virulent. It may be taken internally in ſubſtance, provided it be well divided in form of calx or ſaffron, or even when united with ſome acid, and in a ſaline form, without any danger. It never produces any bad effect, when applied in ſuitable quantity and circumſtances.

The great medicinal virtue of iron is cauſed by its tonic and ſtrengthening qualities. It produces a ſlight and gentle irritation of the fibres, the effect of which is, to conſtringe the ſenſible organic parts upon which it acts, and to encreaſe their force and elaſticity.

Iron particularly acts upon the fibres, and the veſſels of the ſtomach and inteſtines: hence it produces excellent effects in all diſeaſes which proceed from laxity and inactivity of the digeſtive organs; ſuch are crudities, bad digeſtions accompanied with diarrhea, flatulencies, flatulent colics, &c. and in diſeaſes which proceed from the former, as megrims, many hyſterical, hypochondriacal, and melancholic affections, intermittent fevers, tertians and quartans, &c.

Iron has alſo been always conſidered and adminiſtered by the beſt practitioners as a reſolving and aperitive remedy. Stahl, however, and ſeveral other good phyſicians and modern chemiſts, acknowledge no other but the tonic and ſtrengthening qualities of iron. If their opinion be well founded, the caſes in which iron has produced a reſolving and aperitive effect, are ſuch where the obſtructions, and the defect of ſecretions and excretions, have proceeded from weakneſs and re-

(*s*) Iron like other metals is ſaid to conſiſt of earth, phlogiſton, and a metallic or mercurial principle. Teichmeyer relates an experiment by which the exiſtence of the mercurial principle is pretended to be proved. He ſays, that by diſtilling iron filings, which had been expoſed during a year to the air, then triturated, and afterwards expoſed another year to the air, he had obtained a hard matter which ſtuck to the neck of the veſſel, and along with it ſome mercury.

Concerning the *ſmelting of iron ores*, and the other parts of the *Metallurgical Hiſtory of Iron*, *ſee* SMELTING *of* ORES *of* IRON; *and* STEEL.

laxation.

laxation of the fibres and of the veſſels, rather than from a craſſitude of humors; as in the chloroſis, in ſome kinds of jaundice, and in other diſeaſes of the ſame ſort.

The excrements of perſons uſing martial remedies are blackiſh, or even black, which proceeds from a mixture of this metal diſſolved with the aliments. This proves, that if iron penetrates farther than the primæ viæ, it muſt be in very ſmall quantity, ſince the greateſt part of it is ejected with the excrements.

As the principal effect of iron is to change the tone, the tenſion, and the ſpring of the ſolid parts of the body, this effect cannot be continued without a continuance of the martial remedy for ſome conſiderable time; otherwiſe only a tranſient relief would be given, and the diſeaſe would ſoon recur.

CCCXCIV. ISINGLASS. (*t*)

CCCXCV. JUICES *of* PLANTS. The juices of ſeveral plants are expreſſed to obtain their eſſential ſalts, and for ſeveral medicinal purpoſes, with intention either to be uſed without further preparation, or to be made into ſyrups and extracts.

The general method of extracting theſe juices is, by pounding the plant in a marble mortar, and then by putting it into a preſs. Thus is obtained a muddy and green liquor, which generally requires to be clarified, as we ſhall ſoon obſerve.

The juices of all plants are not extracted with equal eaſe. Some plants even when freſh contain ſo little juice, that water muſt be added while they are pounded, otherwiſe ſcarcely any juice would be obtained by expreſſion. Other plants which contain a conſiderable quantity of juice, furniſh by expreſſion but a ſmall quantity of it, becauſe they contain alſo much mucilage, which renders the juice ſo viſcid that it cannot flow. Water muſt alſo be added to theſe plants to obtain their juice.

The juices thus obtained from vegetables by a mechanical method are not, properly ſpeaking, one of their principles, but rather a collection of all the proximate principles of plants which are ſoluble in water; ſuch as the ſaponaceous extractive matter, the mucilage, the odoriferous principle, all the ſaline and ſaccharine ſubſtances; all which are diſſolved in the water of the vegetation of the plants. Beſides all theſe matters, the juice contains ſome part of the reſinous ſubſtance, and the green coloring matter, which in almoſt all vegetables is of a reſinous nature (*u*). Theſe two latter ſubſtances, not being ſoluble in water, are only interpoſed between the parts of the other principles which are diſſolved in the juice, and conſequently diſturb its tranſparency. They nevertheleſs adhere together in a certain degree, and ſo ſtrongly in moſt juices, that they cannot be ſeparated by filtration alone.

(*t*) ISINGLASS is a glue prepared by boiling the ſkin, tail, fins, ſtomach, inteſtines, and bladder of a certain large fiſh frequent in the Ruſſian ſeas and large rivers. It is totally ſoluble in water, but not at all in rectified ſpirit of wine. From eight ounces of iſinglaſs were obtained, by diſtillation, four ounces and two drams of urinous ſpirit, half an ounce of concrete volatile ſalt, an ounce and a half of empyreumatic oil, half a ſcruple of fixed ſalt, and nine drams of earth. Iſinglaſs is employed as a glue for many purpoſes, and for fining wines. *Neuman.*

(*u*) The coloring ſubſtance of vegetables does not ſeem to be a reſinous or gummy matter, but only to adhere accidentally to the reſinous or gummy matters of plants; for when it has been ſeparated from theſe ſo as to form with earth of allum the precipitates called *lakes*, it is not ſoluble either by water or by ſpirit of wine. *See* DYEING.

When

When therefore these juices are to be clarified, some previous preparations must be used by which the filtration may be facilitated. Juices which are acid, and not very mucilaginous, are spontaneously clarified by rest and gentle heat. The juices of most antiscorbutic plants abounding in saline volatile principles, may be disposed to filtration merely by immersion in boiling water; and as they may be contained in closed bottles while they are thus heated in a water-bath, their saline volatile part, in which their medicinal qualities chiefly consist, may thus be preserved. Fermentation is also an effectual method of clarifying juices which are susceptible of it; for all liquors which have fermented, clarify spontaneously after fermentation. But this method is not used to clarify juices, because many of them are susceptible of only an imperfect fermentation, and because the qualities of most of them are injured by that process.

The method of clarification most generally used, and indispensably necessary for those juices which contain much mucilage, is by boiling with the white of an egg. This matter, which has the property of coagulating in boiling water, and of uniting with mucilage, does accordingly, when added to the juice of plants, unite with and coagulate their mucilage, and separates it from the juice in form of scum, together with the greatest part of the resinous and earthy matters which disturb its transparency. And as any of these resinous matters which may remain in the liquor, after this boiling with the whites of eggs, are no longer retained by the mucilage, they may easily be separated by filtration. *See* FILTRATION.

The juices, especially before they are clarified, contain almost all the same principles as the plant itself, because in the operation by which they are extracted no decomposition happens, but every thing remains, as to its nature, in the same state as in the plant. The principles contained in the juice are only separated from the grosser, oily, earthy, and resinous parts, which compose the solid matter that remains under the press. These juices, when well prepared, have therefore exactly the same medicinal qualities as the plants from which they are obtained. They must evidently differ from each other as to the nature and proportions of the principles with which they are impregnated, as much as the plants from which they are extracted differ from each other in those respects.

CCCXCVI. IVORY-BLACK. *(x)*

CCCXCVII. JUPITER. By this name the old chemists distinguished tin. *See* TIN.

(x) *See the article* BLACK.

K.

CCCXCVIII. KALI. (*y*)

CCCXCIX. KAOLIN. (*z*)

CCCC. KARAT. This name is applied to the proportional parts which are supposed to be in any mass of gold, the value or purity of which is to be ascertained. When therefore gold is considered with regard to its degree of purity, the whole mass of it, whatever be its real weight, is supposed to be divided into 24 parts, and these parts are called karats. Hence, when gold is entirely pure, and without alloy, it is called gold of 24 karats. If it contains $\frac{1}{24}$ part of alloy, it is called gold of 23 karats, because in such a mass $\frac{23}{24}$ are gold, and $\frac{1}{24}$ is alloy. If the mass of gold be $\frac{2}{24}$ or $\frac{1}{12}$ of alloy, it is called gold of 22 karats, and so on. For greater precision, the karat is supposed to be subdivided into 32 parts, which have no other name than the thirty-second parts of a karat (*a*). *See* ESSAY *of the* VALUE *of* GOLD *and of* SILVER.

(*y*) KALI is a maritime plant, from the ashes of which a considerable quantity of mineral fixed alkali is obtained by lixiviation. *See* ALKALI (FIXED MINERAL). Henkel informs us, that by boiling the plant in water, and by evaporating the decoction, he obtained a considerable quantity of sea-salt.

(*z*) KAOLIN is the name of an earth which is used as one of the two ingredients of the oriental porcelain. Some of this earth was brought from China, and examined by Mr. Reaumur. He found that it was perfectly unfusible by fire. He believed that it was a talky earth; but the author of this Dictionary justly observes, that it is more probably an argillaceous earth, from its forming a tenacious paste with the other ingredient called *petuntse*, which has no tenacity. Mr. Bomare says, that by analysing some Chinese kaolin, he found it was a compound earth consisting of clay, to which it owed its tenacity; of calcareous earth, which gave it a mealy appearance; of sparkling particles of mica, and of small gravel or particles of quartz crystals. He says, that he has found a similar earth upon a stratum of granite, and conjectures that it may be a decomposed granite. *See* PORCELAIN.

(*a*) The karat, or carat, in England is divided into four parts only, called grains, and in Germany into twelve parts. Standard gold in England is gold of twenty-two carats, that is, which contains $\frac{1}{12}$ part of alloy, which is generally an equal mixture of copper and silver; as the whole proportion of the copper would make the gold too high-colored, and the whole proportion of the silver would make it too pale.

The word karat, when applied to diamonds, signifies a real weight of four grains.

CCCCI. K E R M E S. (*b*)

CCCCII. K E R M E S M I N E R A L. Kermes mineral, so called from its color, which resembles that of vegetable kermes, is one of the most important antimonial preparations, both with regard to its chemical phenomena and to its medicinal uses.

The use of kermes mineral was not established in medicine before the beginning of this century. Some chemists, indeed, amongst others Glauber and Lemeri, had before that time mentioned in their works several preparations of antimony which approach more or less to kermes; but these preparations being little known, were confounded with many others which are entirely neglected, although much praised by their authors.

The fame of kermes was occasioned by Friar Simon, apothecary to the Chartreux Friars. This friar received this preparation from a surgeon called La Ligerie, who had procured it from a German apothecary who had been a scholar of the famous Glauber. Friar Simon, from the commendations given to this new remedy by La Ligerie, administered it to a Chartreux Friar, who was dangerously ill of a violent peripneumony, by which the Friar was suddenly, and as it had been miraculously, cured. From that time the Friar apothecary published the virtue of his remedy. Several other remarkable cures were performed by means of kermes. The public believed in its medicinal qualities, and called it *Powder of Chartreux*; because it was prepared only in the apothecary's shop belonging to these monks. The reputation of kermes extended itself more and more; till at length the Duke of Orleans, then Regent of France, procured the publication of the process by La Ligerie.

This is the history of kermes, as it is related by Mr. Baron, in his edition of Lemeri's Chemistry. Although the process for making this preparation be very accurately described in this and other books, we shall treat of it in detail, because it is a matter of much importance.

The process for kermes, published by La Ligerie, consists in boiling, during two hours, pulverised crude antimony in the fourth part of its weight of the liquor of nitre fixed by coals, and twice its weight of pure water: at the end of this time the liquor is to be decanted and filtrated, while boiling, through brown paper. It continues clear while it is boiling hot; but when it cools, it becomes turbid, acquires a red brick color, and again becomes clear by the deposition of a red sediment, which is the kermes. The boiling may be thrice repeated, and each time the same quantity of water is to be added to the antimony, and a fourth part less of the liquor of fixed nitre. The several sediments from these three boilings are to be added together, washed with clean water, till the water acquires no taste; and the kermes is then to be dried. La Ligerie directs, that aqua vitæ shall be once or twice poured upon it and burnt, and the kermes dried again.

(*b*) Kermes are excrescencies formed by insects on the branches and leaves of the scarlet oak. They communicate a red color to water or to spirit of wine. Woollen cloth, previously dipped in a solution of alum and of tartar in water, receives from a decoction of kermes a more durable, but less vivid, scarlet dye than that usually procured from cochineal, together with a solution of tin.

We now proceed to explain the nature of kermes, and the phenomena of its preparation.

Crude antimony is compofed of regulus of antimony and common fulphur, united naturally with each other, as in almoft all metallic minerals. The fixed alkali with which the crude antimony is boiled, although it is diluted with much water, acts upon the fulphur of the antimony, and forms with it liver of fulphur; and as this compound is a folvent of all metallic matters, it diffolves a certain quantity of the regulus of antimony. In this operation then a combination is formed of fixed alkali, of fulphur, and of regulus of antimony. Of thefe three fubftances the fixed alkali only is foluble in water, and is the intermediate fubftance by which the fulphur and regulus are fufpended in the water. But we are to obferve, that the alkali becomes impregnated by this operation, and by boiling, with a larger quantity of regulus, and efpecially of fulphur, than can be fufpended in cold water; hence the decoction of kermes, which is clear, limpid, and colorlefs while boiling hot, becomes turbid, and depofites a fediment while it cools. This compound, therefore, like certain falts, may be kept diffolved in larger quantity by hot than by cold water, and much of it is therefore depofited by cooling.

Further, while the kermes is precipitating, the whole antimoniated liver of fulphur, which is diffolved by the boiling liquor, may be divided into two parts; one of which, that is the kermes, being overcharged with the regulus, and particularly with the fulphur, contains but a little alkali, which it draws along with it during its depofition. The other part, as it contains much more alkali, remains diffolved even in the cold liquor, by means of this larger quantity of alkali. All thefe propofitions are to be explained and demonftrated by the following obfervations.

Firft, when the decoction of kermes is cold, and has formed all its fediment, if, without adding any thing to it, it be heated till it boil, it again entirely re-diffolves the kermes; the fediment difappears; the liquor becomes clear, and by cold is again rendered turbid, and depofites fediment as before. Thus the kermes may be made to precipitate and to re-diffolve as often as we pleafe.

Secondly, by digefting kermes in aqua regia, which diffolves its alkali and regulus, the fulphur is feparated pure. The acids of aqua regia form a nitre and a febrifugal falt of Sylvius with the alkali of the kermes; and if a certain quantity of kermes be melted with black flux, after having deftroyed its fulphur by roafting, a true regulus of antimony may be obtained from it.

Thefe experiments, which were made by Mr. Geoffroy, and the detail of which is found in Memoirs given to the Academy in the years 1734 and 1735, upon the Analyfis of Kermes, fhew evidently the prefence of fulphur, of fixed alkali, and of regulus of antimony, in this compound. From Mr. Geoffroy's experiments we find, that 72 grains of kermes contain about 16 or 17 grains of regulus, 13 or 14 grains of alkaline falt, and 40 or 41 grains of common fulphur.

Thirdly, by repeating the boiling of the liquor upon the antimony, more and more kermes will be formed each time by cooling, as at firft; and this experiment may be repeated a great many times. Mr. Geoffroy fays, that he repeated it 78 times, without any other addition than that of pure water, to fupply that which was loft by evaporation; and that each time a confiderable quantity of

kermes was formed by cooling. This experiment proves, that the alkali transforms the antimony into kermes by overcharging itself with regulus and sulphur, and at each precipitation the kermes does not retain and take with it but a very small quantity of alkali.

Fourthly, if any acid be poured upon the liquor in which the kermes has been formed, and from which it has been entirely separated by cooling, Mr. Beaumé has observed, that this liquor is again rendered turbid, and that a second sediment is formed of a yellow reddish color, which is nothing else than golden sulphur of antimony; that is, regulus of antimony and sulphur mixed together, but in very different proportions, and with different strengths of union, from those in which they are found in the crude antimony. *See* SULPHUR (GOLDEN) *of* ANTIMONY.

After this precipitation, in the liquor a neutral salt is left, which is formed by the contained alkali and the precipitating acid. From this experiment we find, that in the liquor from which the kermes has been deposited, a considerable quantity of antimoniated liver of sulphur remains, which differs from kermes by containing a much larger proportion of alkali; so that it can keep dissolved the regulus and sulphur with which it is united, even when the liquor is cold.

From what has been said concerning the manner in which kermes is formed, and the phenomena presented by this operation, we ought to understand well what it consists of. It is evidently nothing else than an antimoniated liver of sulphur, in which the sulphur predominates, and which contains too little alkali to be soluble in water. On this last article we may observe, that kermes after its spontaneous separation, and before it has been washed, contains much more alkali than after it has been washed; whence, if the kermes has been washed with very hot water, a part of it will be re-dissolved; but as the water always takes away the part which is most alkaline, the kermes which remains at last contains so little alkali, that it is no longer soluble even in boiling water; and then it has all the qualities peculiar to it.

In the processes for several antimonial preparations, a kermes, or compounds like it, are formed. This always happens when crude antimony is treated by fusion with a quantity of alkaline salt, so that an antimoniated liver of sulphur results from it, overcharged with regulus and sulphur; that is, containing more of these two substances than it can keep dissolved in cold water. If any of these combinations be boiled in water, a matter analogous to kermes is always deposited by cooling. This happens, for instance, to the scoria of the regulus of antimony, and in an operation described by Mr. Geoffroy to abridge the process for making kermes by fusion.

To make kermes by fusion, Mr. Geoffroy fuses two parts of antimony with one part of alkaline salt; he powders this matter while yet hot, and keeps it during two hours in boiling water; he then filtrates it, and receives the liquor into more boiling water, from which, when it cools, about six gros of kermes is deposited, when an ounce of antimony has been used. This method of making kermes is much more expeditious, but less perfect; for, as the author confesses, the kermes produced is not so fine and soft as that made in the ordinary method.

Mr

Mr. Lemeri the elder mentions also, in his Treatise concerning Antimony, an operation from which his son pretends that kermes may be obtained. This operation consists in digesting and afterwards boiling powdered crude antimony in a very pure liquor of fixed nitre. This liquor, if it be in sufficient quantity, is capable of dissolving quickly and entirely powdered crude antimony, and we cannot doubt but that by cooling a considerable quantity of a substance very analogous to kermes will be produced. Nevertheless, none of these short methods of making kermes is directed by dispensatories, or by the best books for describing the preparations of chemical remedies; and we must allow, that this is done prudently; for, besides that all these kinds of kermes may be suspected to be less fine, or more charged with reguline parts than that which is prepared by the ordinary process; when the constant observation of medical practitioners has ascertained the effects of a compound remedy; such a remedy ought to be considered as it were consecrated by a respectable kind of empiricism, against which the finest theory and most specious reasonings ought not to avail. The least reformation or innovation ought then to be considered as a blameable rashness, particularly when a remedy of such importance is concerned.

Kermes is used in medicine only, and from it singularly excellent effects may be produced, when administered by able physicians. In kermes are united the exciting and evacuant virtues of the emetic preparations of antimony, with the tonic, dividing, aperitive, and resolving properties of the liver of sulphur; that is to say, that it is capable of answering two principal indications in the treatment of many acute and chronic diseases. Properly managed, it may become an emetic, purgative, a diuretic, a sudorific, or an expectorant, as is required, and it is always attenuating and resolving. When seven or eight grains are taken at once, it chiefly acts upon the primæ viæ, generally as an emetic and as a purgative. A dose of three or four grains is seldom emetic, and more frequently purgative.

When taken in these quantities as an evacuant, a little of it passes also into the viæ secundæ & tertiæ. When it is administered in smaller doses, it passes almost entirely into the lacteal, blood, and lymphatic vessels. In these it occasions such spasms and oscillations as it does in the primæ viæ; so that it encreases all secretions and excretions, but particularly those of urine, sweat, and expectoration, according to the dose, to the nature of the disease, and to the disposition of the patient. It produces singularly good effects in those diseases of the breast which proceed from fullness and obstruction.

Kermes may be administered in linctus's, in oily or in cordial potions, in any vehicle; or incorporated in a bolus, with other suitable remedies. One precaution, hitherto little observed, is very necessary, that is, not to join it with acid matters, if it is intended to act as kermes. Anti-acid and absorbent substances ought to be joined with it, if the patient has an acid in the primæ viæ, or an acescent disposition; for, as these acids saturate the alkali by which the kermes is rendered an antimoniated liver of sulphur, and by which alone it differs from golden sulphur of antimony, they accordingly render the kermes entirely similar to the golden sulphur of antimony, the properties of which are very different from those of kermes. *See* SULPHUR (GOLDEN) *of* ANTIMONY. In some cases, we certainly ought to prefer the unwashed kermes to that which

has been washed, and therefore apothecaries ought to keep both the kinds, as Mr. Baron proposes in his edition of Lemeri's Chemistry.

CCCII. KINGDOMS. Most naturalists and chemists divide all natural bodies into three great classes, which they call kingdoms. These are the *mineral*, the *vegetable*, and the *animal kingdoms*.

This great and first division is founded on this consideration, that any plant or vegetable which is produced, which grows, which is organised, which contains a seed, and which produces its like, seems to be a being very distinct and different from a stone or a metal, in which we at most observe only a regular arrangement of parts, but not a true organisation, and which contains no seed by which it is capable of reproduction; and another foundation of this division is, that an animal differs no less from a simple plant, by sensation, by the use of its senses, and by the power of voluntary motion which it possesses, while these qualities do not belong to any thing which is merely vegetable.

But notwithstanding these marks so distinctive, some philosophers pretend, that this division into classes of natural bodies is only ideal. They affirm, that by observing nature attentively, we may perceive that all her productions are connected together by an uninterrupted chain; and that by surveying the several beings, we must be convinced that any one being differs very little from some other two, betwixt which it seems to be placed; so that we may descend from the most perfect animal to the rudest mineral by insensible degrees, and without finding any interval from which a division might be made.

This idea is certainly great, sublime, and not improbable; for if we compare a *polypus* with the *sensitive plant*, or a *lichen* with a beautiful ore of ramified native silver, we shall be inclined to consider this opinion as conformable to the plan of nature.

The opinions of naturalists are therefore divided upon this subject, and each opinion seems to be founded on observations, analogies, and reasonings more or less conclusive. But as the discussion of this matter is foreign to our subject, we shall not enter into a more particular detail, but we shall consider natural bodies only in a chemical view; that is to say, relatively to the several principles which we obtain in the analysis of those bodies. We proceed therefore to shew what experiments have taught us on this subject. In the decomposition of all beings truly living, organised, and containing within themselves a seed by which they may be reproduced, such as vegetables and animals, we always obtain an inflammable, fat, or oily substance; and on the contrary, we do not find the smallest trace of this principle in any substance purely mineral, not even in sulphur, which is the most inflammable of all these substances. On the other side, if we carefully examine and compare with each other the analogous principles obtained from the three kingdoms, such as the saline substances obtained in the analysis of animals, vegetables, and minerals; we shall easily perceive that all the saline matter which comes from the vegetable or animal kingdoms is altered by oil, while all the saline matter which comes from the mineral kingdom is entirely free from oil.

We ought to observe here, that because any matter is found in one or more individuals of any kingdom, we must not therefore conclude, that it belongs to the kingdom of such individuals; for we may be convinced from a slight observation of nature, that by a thousand combinations, and particular circumstances,

substances

substances of quite different classes or kingdoms are daily found mixed and confounded together. Thus, for example, within the earth, and even at great depths, that is, in the region appropriated to minerals, sometimes substances are found evidently oily, such as all *bitumens*: but we at the same time can prove, and all the observations of natural history prove, that these oily substances are only accidentally within the earth, and that they proceed from the vegetable or animal bodies which have been buried in the earth by some of those great revolutions which have happened from time to time upon the surface of our globe. Also in decomposing several vegetables and animals, salts are obtained; such as common salt, Glauber's salt, and others, which contain nothing oily, and which are consequently matters evidently mineral. But, on the other side, we are certain that these mineral salts are extraneous to the animals and vegetables in which they are found; that they are only introduced into these living bodies, because they happen to be mixed with the matters which have been applied to them as aliments, and that they ought not to be numbered amongst their principles. The proof of this is, that not only the quantity of these mineral salts is not uniform in animals and vegetables, but also, that not a particle of such salts is contained in some plants and animals equally strong and healthy, and of the same species as those in which these salts have generally been observed.

In the second place, we observe, that oils do only exist in the proximate principles of vegetables and animals; that is, in those of their principles which enter immediately into their composition, when these principles have not been altered by further decompositions, and consequently when they still preserve their animal or vegetable character; for, by a natural putrefaction continued during a long time, or by chemical operations, not only the materials of which animal and vegetable bodies are formed, may be deprived entirely of oil, but also this oil may itself be entirely destroyed or decomposed. These substances in that state contain nothing by which they can be distinguished from minerals. The earths, for example, of vegetables and animals, when they are deprived, by a sufficient calcination, of all inflammable matter, become entirely similar to the calcareous and argillaceous earths found within the globe, and which may be considered as mineral substances, although probably they have been formerly a part of animal and vegetable bodies. Further, if vegetable acids were deprived of all their oily parts, which is perhaps very possible, then they would entirely resemble the mineral acids, probably the vitriolic and marine, and would lose all the characteristic properties of vegetable acids.

Hence we conclude, that when we consider natural bodies in a chemical view, we ought to divide them into two great classes. The first class is of substances inanimate, unorganised, and the principles of which have a degree of simplicity which is essential to them: these are minerals. The other class contains all those bodies which not only have been distinctly organized, but which also contain an oily matter, which is no where found in substances which have not made part of animate bodies, and which, by combining with all the other principles of these animate bodies, distinguishes these principles from those of minerals by a less degree of simplicity. This second class contains vegetables and animals. We ought also to remark, that the oil contained in vegetable and animal substances renders them susceptible of fermentation, properly so called,

 which

which cannot by any means take place in any mineral. *See* ACIDS, BITUMINS, FERMENTATION, OILS, PUTREFACTION, *and* EARTHS.

We ſhall now proceed to examine, if, by comparing the principles obtained in the decompoſition of vegetables with thoſe obtained in the decompoſition of animals, we can find ſome eſſential character by which theſe two kingdoms may be chemically diſtinguiſhed, in the ſame manner as we have ſeen that both of them may be diſtinguiſhed from minerals. From experiments we indeed learn, that the principles of vegetables differ evidently enough from thoſe of animals; that in general the ſaline principles of the former are acid, and are transformable in great meaſure into fixed alkali by incineration, while the principles of the latter are volatile alkalis, or eaſily changeable into theſe; that vegetables are much farther removed from putrefaction than animals; laſtly, that oils truly animal have a character different from vegetable oils, and are in general more attenuated, or at leaſt more diſpoſed to be attenuated and volatiliſed. But we muſt, at the ſame time, confeſs, that theſe differences are not clear and deciſive, like thoſe betwixt theſe two kingdoms and the mineral kingdom; for we do not find any eſſential principle, either in animals or in vegetables, which is not alſo to be found in the other. In ſome plants, chiefly the cruciform, as much volatile alkali, as little fixed alkali, and as much diſpoſition to putrify, are found as in animal matters; and thence we conclude, that if theſe two great claſſes of natural bodies differ chemically from each other, this difference proceeds only from the quantities or proportions of their ſeveral principles and properties, and not from any thing diſtinct and peculiar, nor is it ſimilar to the manner in which both vegetable and animal ſubſtances differ from minerals, namely, by containing an oil, and poſſeſſing a fermentable quality. Beſides, the degrees of the chemical differences betwixt theſe three great claſſes of natural bodies are found to be the ſame, in whatever manner we conſider them or compare them together.

CCCIV. KUPFER-NICKEL. *(e)*

(e) KUPFER-NICKEL is a reddiſh yellow mineral containing the ſemi-metal called nickel, together with iron and cobalt, mineraliſed by arſenic and by ſulphur. It is ſometimes of a vitreous texture, ſometimes fine-grained, and ſometimes conſiſting of ſcaly particles. *See* NICKEL.

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CCCCV. LABORATORY (CHEMICAL). As chemiſtry is a ſcience founded entirely on experiments, we cannot hope to underſtand it well, or to poſſeſs a certain degree of it, without making ſuch experiments as ſhall verify moſt of the known fundamental operations, and alſo ſuch as reaſoning, analogy, and the ſpirit of inquiry, never fail to ſuggeſt to thoſe whoſe taſte and ſuitable talents lead them to this eſſential part of experimental philoſophy. Beſides, when a perſon himſelf obſerves, and operates, he muſt perceive, even in the moſt common operations, a great variety of ſmall facts, which muſt neceſſarily be known, but which are not mentioned either in books or in memoirs, becauſe they are too numerous, and would appear too minute. Laſtly, how many qualities are in the ſeveral chemical agents, of which no juſt notion can be given by writing, and which are perfectly well known as ſoon as they have been once made to ſtrike our ſenſes?

Whoever therefore would become a chemiſt, muſt indiſpenſably have a laboratory furniſhed with the moſt neceſſary inſtruments for the practice of this ſcience; and we therefore think proper to mention what theſe are. Our intention is not to ſpeak in this article of laboratories deſigned for operations in the great, nor of thoſe which are appropriated to ſome particular part of chemiſtry; as, for example, to eſſays, enamels, &c. but of the kind of laboratory which is proper for a philoſophical chemiſt, to make occaſionally, in ſmall, any chemical operation whatever. Such a laboratory neceſſarily occaſions certain expences, but not ſo much as is generally believed, when the operator knows how to manage his utenſils, and to employ only the proper quantity of the ſeveral ſubſtances upon which he operates; and laſtly, when he chuſes the leaſt expenſive methods of attaining his purpoſes.

Many people think, that a laboratory level with the ground is moſt convenient, for the ſake of water, pounding, waſhing, &c. It certainly has theſe advantages; but it is alſo ſubject to a very great inconvenience from moiſture.

Conſtant moiſture, tho' not very conſiderable and ſenſible in many reſpects, is a very great inconvenience in a chemical laboratory. In ſuch a place, moſt ſaline matters become moiſt in time; the inſcriptions fall off, or are effaced; the bellows rot; the metals ruſt; the furnaces moulder, and every thing almoſt ſpoils. A laboratory therefore is more advantageouſly placed above than below the ground, that it may be as dry as is poſſible. The air muſt have free acceſs to it, and it muſt even be ſo conſtructed, that, by means of two or more oppoſite openings, a current of air may be admitted to carry off any noxious vapors or duſt.

In the laboratory a chimney ought to be conſtructed, ſo high that a perſon may eaſily ſtand under it, and as extenſive as is poſſible; that is, from one wall to another. The tube of this chimney ought to be as high as is poſſible, and ſufficiently contracted to make a good draught. As charcoal only is burnt under this chimney, no ſoot is collected in it; and therefore it need not be ſo wide as to allow a chimney-ſweeper to paſs up into it.

Under this chimney may be conſtructed ſome brick-furnaces, particularly a melting furnace, a furnace for diſtilling with an alembic, and one or two ovens like thoſe in kitchens. The reſt of the ſpace ought to be filled up with ſtands of different heights, from a foot to a foot and a half, on which portable furnaces of all kinds are to be placed. Theſe furnaces are the moſt convenient, from the facility of diſpoſing them at pleaſure; and they are the only furnaces which are neceſſary in a ſmall laboratory. A double bellows of moderate ſize muſt alſo be placed as commodiouſly under the chimney, or as near as the place will allow. Theſe bellows are ſometimes mounted in a portable frame, which is ſufficiently convenient when the bellows is not more than eighteen or twenty inches. Theſe bellows ought to have a pipe directed towards the hearth where the forge is to be placed.

The neceſſary furnaces are, the ſimple furnace, for diſtilling with a copper alembic; a lamp furnace; two reverberatory furnaces, of different ſizes, for diſtilling with retorts; an air or melting furnace; an eſſay furnace, and a forge-furnace. *See the enumeration and deſcription of theſe furnaces under the words* FORGE *and* FURNACE. *See alſo* PLATES.

Under the chimney, at a convenient height, muſt be a row of hooks driven into the back and ſide walls; upon which are to be hung ſmall ſhovels, iron pans; tongs; ſtraight, crooked, and circular pincers; pokers; iron rods, and other utenſils for diſpoſing the fuel and managing the crucibles.

To the walls of the laboratory ought to be faſtened ſhelves of different breadths and heights; or theſe ſhelves may be ſuſpended by hooks. The ſhelves are to contain glaſs veſſels, and the products of operations, and ought to be in as great a number as is poſſible. In a laboratory where many experiments are made, one cannot have too many ſhelves.

The moſt convenient place for a ſtone or leaden fountain to contain water is a corner of the laboratory, and under it a ciſtern ought to be placed with a pipe by which the water poured into it may diſcharge itſelf. As the veſſels are always cleaned under this fountain, cloths and bottle bruſhes ought to be hung upon hooks faſtened in the walls near it.

In the middle of the laboratory a large table is to be placed, on which mixtures are to be made, preparations for operations, ſolutions, precipitations,

ſmall

ſmall filtrations; in a word, whatever does not require fire, excepting that of a lamp.

In convenient parts of the laboratory, are to be placed blocks of wood upon mats; one of which is to ſupport a middle-ſized iron mortar, another to ſupport a middle-ſized marble, or rather hard-ſtone mortar, a third to ſupport an anvil. Near the mortars are to be hung ſearces of different ſizes and fineneſs; and near the anvil are hung a hammer, files, raſps, ſmall pincers, ſciſſars, ſheers, and other ſmall utenſils, neceſſary to give metals a form proper for the ſeveral operations.

Two moveable treſtles ought to be in a laboratory, which may ſerve to ſupport a large filter mounted upon a frame, when it is required. This apparatus is removed occaſionally to the moſt convenient place. *See* FILTRATION *and* FILTER.

Charcoal is an important article in a laboratory; and it therefore muſt be placed within reach: but as the black duſt which flies about it whenever it is ſtirred is apt to ſoil every thing in the laboratory, it had better be in ſome place near the laboratory, together with ſome furze, which is very convenient for kindling fires quickly. This place ſerves, at the ſame time, for containing bulky things which are not often wanted; ſuch as furnaces, bricks, tiles, clay, fire-clay, quicklime, ſand, and many other things neceſſary for chemical operations.

Laſtly, a middle-ſized table, with ſolid feet, ought to be enumerated amongſt the large moveables of a laboratory, the uſe of which is to ſupport a porphyry, or levigating ſtone, or rather a very hard and denſe grit-ſtone, together with a grinder made of the ſame kind of ſtone.

The other ſmall moveables or utenſils of a laboratory are, ſmall hand-mortars of marble, iron, and glaſs, and their peſtles; earthen, ſtone, metal, and glaſs veſſels; *an enumeration of which ſee under the article* VESSELS, *and a deſcription under their reſpective names.*

Some white writing-paper, and ſome paper not glued for filtrations; a large number of clean ſtraws, eight or ten inches long, for ſtirring mixtures in glaſſes, and for ſupporting paper filters placed in glaſs funnels.

Glaſs tubes for ſtirring and mixing corroſive liquors; ſpatulas of wood, ivory, metal, and of glaſs.

Thin paſteboards and horns, very convenient for collecting matters bruiſed with water upon the levigating ſtone or in mortars; corks of all ſizes; bladders and linen ſtrips for luting veſſels. *See* LUTES.

A good portable pair of bellows; a good ſteel, for ſtriking fire; a glue pot, with its little bruſh; laſtly, a great many boxes of various ſizes, for containing moſt of the above-mentioned things, and which are to be placed upon the ſhelves.

Beſides theſe things, ſome ſubſtances are ſo neceſſary in moſt chemical operations, that they may be conſidered as inſtruments neceſſary for the practice of this ſcience. Theſe ſubſtances are:

All metals and ſemi-metals, which ought to be very pure.

Vitriolic acid, ſome of which ought to be concentrated and rectified, and alſo ſome of that ſort commonly ſold by druggiſts.

Aqua

Aqua fortis, such as is commonly sold, and is cheap; also spirit of nitre moderately strong, but very pure: the same acid very pure, concentrated, and smoking.

Common spirit of salt. Some of the same acid very pure, very strong, and smoking. All these acids ought to be kept in crystal glass bottles, and closed with glass stoppers.

Some distilled vinegar, which may be kept in an ordinary bottle; some radical vinegar, which ought to be kept in a bottle with a glass stopper; some cream of tartar, in an earthen or glass vessel, or in a box.

Common fixed vegetable alkali, very dry, such as pot-ash, which must be kept in a well closed bottle. The same alkali in a liquid state.

Very pure salt of tartar, some dry, and some liquid.

Mineral alkali, liquid; that is, a solution of soda. The same alkali dry and very pure; that is, well formed crystals of soda.

The two fixed alkalis liquid, and rendered caustic by quicklime. Alkalis, particularly those which are caustic, ought to be kept in bottles with glass stoppers. Some phlogisticated fixed alkali, or even saturated so as to be fit for making Prussian blue.

Some dry liver of sulphur kept in a well closed bottle. The same liquid. Some common sulphur.

Very pure alkali of sal ammoniac, disengaged by a fixed alkali, some solid, and some liquid, kept in a bottle with a glass stopper.

Fluor spirit of sal ammoniac disengaged by quicklime, as strong as is possible. Some of this spirit may be kept of less strength.

Lime water, and quicklime, in well closed bottles.

The purest and highest rectified spirit of wine.

Good vitriolic ether.

Rectified essential oil of turpentine; oil of olives; soap.

Galls; syrup of violets; tincture of turnsol, or turnsol in rags; fine blue paper; river or distilled rain-water.

Besides these substances, most of which are solvents, certain neutral salts ought to be had which are frequently used in chemical operations, or are difficultly prepared. These are:

Vitriolated tartar; alum, and calcined alum; green vitriol; blue vitriol; nitre; decrepitated common salt; some of the same salt very pure dissolved in distilled water; purified sal ammoniac; calcined borax; sedative salt.

A pure solution of silver in spirit of nitre; a solution of mercury in the same acid; butter of antimony. All these to be kept in bottles with glass stoppers. Corrosive sublimate.

Ceruss; litharge; minium; sand washed and ground; white marble; washed chalk; glass of lead; glass of borax. *See the nature and properties of all these matters under their respective names.*

A person, provided with the above-mentioned instruments and substances, may at once perform any chemical experiment. He may indeed occasionally want several neutral salts which have not been named; but all these salts with bases of earths, metals, fixed or volatile alkalis, may be easily and instantly prepared, as most of them do not require distillation or sublimation. They may nevertheless,

neverthelefs, if they are not too numerous, be all previoufly prepared and kept ready for any occafions.

We ought not to finifh this article without making fome obfervations important to thofe who propofe to give themfelves up to the ftudy of chemiftry. They ought to be well perfuaded that method, order, and cleanlinefs, are effentially neceffary in a chemical laboratory. Every veffel and utenfil ought to be well cleanfed as often as it is ufed, and put again into its place: infcriptions ought to be faftened upon all the fubftances. Thefe cares, which feem to be trifling, are however very fatiguing and tedious; but they alfo are very important, though frequently little obferved. When a perfon is keenly engaged, experiments fucceed each other quickly; fome feem nearly to decide the matter, and others fuggeft new ideas: he cannot but proceed to them immediately, and he is led from one to another: he thinks he fhall eafily know again the products of the firft experiments, and therefore he does not take time to put them in order: he profecutes with eagernefs the experiments which he has laft thought of; and, in the mean time, the veffels employed, the glaffes and bottles filled, fo accumulate, that he cannot any longer diftinguifh them; or, at leaft, he is uncertain concerning many of his former products. This evil is encreafed if a new feries of operations fucceed, and occupy all the laboratory; or if he is obliged to quit it for fome time: every thing then goes into confufion. Thence it frequently happens that he lofes the fruits of much labor, and that he muft throw away almoft all the products of his experiments.

The only method of avoiding thefe inconveniences is to employ the cares and attentions above-mentioned. It is indeed difagreeable to ftop continually in the middle of the moft interefting refearches, and to employ a very precious and confiderable time in cleaning veffels, arranging them, faftening infcriptions on them, &c. Thefe employments are capable of cooling or retarding the progrefs of genius, and are tedious and difguftful; but they are neverthelefs neceffary. Thofe perfons whofe fortune enables them to have an affiftant operator, on whofe exactnefs and intelligence they can depend, avoid many of thefe difagreeable circumftances; but they ought neverthelefs to attend to the execution of thefe things. We cannot depend too much on ourfelves in thefe matters, however minute, on account of their confequences. This becomes even indifpenfable when the experiments are to be kept fecret, at leaft for a time; which is often neceffary in chemiftry.

When new refearches and inquiries are made, the mixtures, refults, and products of all the operations ought to be kept a long time, diftinctly labelled and regiftered; for thefe things, when kept fome time, frequently prefent phenomena that were not at all fufpected. Many fine difcoveries in chemiftry have been made in this manner, and many have certainly been loft by throwing away too haftily or neglecting the products.

Laftly, we cannot too much recommend to chemical operators to be exceedingly upon their guard againft impofing and deceitful experiments, which frequently prefent themfelves in practice. A circumftance feemingly unimportant, or not eafily perceptible, is frequently fufficient to give the appearance of a great difcovery, by means of certain effects, which, neverthelefs, are found to proceed from fome other caufe. Chemical experiments depend on fo many acceffary things, that all of them can feldom be attended to, particularly when

the ſubject is new: hence we frequently find that very different reſults proceed from the ſame experiment, made at different times. We therefore muſt not decide after the firſt ſucceſs; but the experiment muſt be repeated ſeveral times, and even varied, till no doubt can remain.

Further, as chemiſtry offers many views for the improvement of many important arts; as it preſents proſpects of many uſeful and profitable diſcoveries; thoſe who apply their labors in this way ought to be exceedingly circumſpect not to be led into an uſeleſs expence of money and time. Thoſe reſearches which have ſome analogy with the philoſopher's ſtone, from the hopes of wealth which they ſuggeſt, are alſo attended with ſimilar danger. In a certain ſet of experiments ſome one is generally of an impoſing appearance, although in reality it be nothing more. Chemiſtry is full of theſe half-ſucceſſes, which ſerve only to deceive the unwary, to multiply the number of trials, and to lead to great expence before the fruitleſſneſs of the ſearch be diſcovered. By theſe reflexions we do not intend to divert from all ſuch reſearches thoſe whoſe taſte and talents render them fit for them; on the contrary, we acknowledge that the improvement of the arts, and the diſcovery of new objects of manufacture and commerce, are undoubtedly the fineſt and moſt intereſting part of chemiſtry, and which make that ſcience truly valuable; for without theſe ends what would chemiſtry be but a ſcience purely theoretical, capable of employing only ſome abſtract and ſpeculative minds, but uſeleſs to ſociety? We acknowledge alſo, that the ſucceſſes in this kind of chemical inquiry are not rare; and that their authors have ſometimes acquired fortunes, ſo much the more honorable as being the fruits of their talents and induſtry. But we repeat, that in theſe reſearches, the more dazzling and near any ſucceſs appears, the more circumſpection and even diſtruſt is neceſſary.

CCCCVI. LAC LUNÆ. (d)

CCCCVII. LAC. (e)

CCCCVIII. LAPIS INFERNALIS. *See* CAUSTIC.

(d) LAC LUNÆ, *Agaricus Mineralis*, is a very light, ſpongy, friable, and white calcareous earth. *See* EARTH (CALCAREOUS).

(e) LAC, *Lacca*, or *Gum-lac*, is a kind of wax, of which a ſpecies of winged ants form cells upon trees, like honeycombs. In theſe cells remain ſome of the dead inſects, which give a red color to the whole ſubſtance of the lac. That called *ſtick-lac* is the wax adhering to ſome of the ſmall branches of the tree, and which is unprepared. This lac, when ſeparated from the adhering ſticks, and groſsly powdered, and deprived of its color by digeſtion with menſtruums, for the ſake of dyes, and other purpoſes, is called *ſeed-lac*; and laſtly, when the ſtick-lac is freed from impurities, by melting it over a gentle fire, and formed into cakes, it is called *ſhell-lac*. Lac is unſoluble in water, and difficultly ſoluble in ſpirit of wine, which for that purpoſe muſt be well dephlegmated. According to Neuman, ſixteen ounces of ſeed-lac, diſtilled in an open fire, yielded nine ounces and ſix drams of a butter or thick oil, one ounce ſix drams of a watery liquor neither acid nor alkaline, and a reſiduum weighing two ounces and a half. It is uſed in the preparation of ſpirit varniſhes, for the making of ſealing-wax, and as a coloring material for dying ſcarlet. The color given by lac is leſs beautiful, but more durable, than that given by cochineal. To render the coloring matter of the lac diffuſible in water, ſo as to be applied to the ſtuffs to be dyed, Mr. Hellot directs the following proceſs: Let ſome powdered gum-lac be digeſted during two hours in a decoction of comfrey root, by which a fine crimſon color is given to the water, and the gum is rendered pale or ſtraw-

CCCCIX. LAPIS LAZULI. (*f*)

CCCCX. LEAD. Lead, called also *Saturn*, is an imperfect metal, white, but darker than tin, the softest, least ductile, least elastic, and least sonorous of all the metals.

It also has the least tenacity; a leaden wire of $\frac{1}{10}$ of an inch in diameter being capable of supporting only $29\frac{1}{4}$ pounds.

This metal has a considerable specific gravity. Next to gold, platina, and mercury, it is the heaviest metal. It loses, when immersed in water, betwixt $\frac{1}{11}$ and $\frac{1}{12}$ part of its weight. A cubic foot of lead weighs 828 pounds.

straw-colored. To this tincture, poured off clear, let a solution of alum be added; and when the coloring matter has subsided, let it be separated from the clear liquor, and dried. It will weigh about $\frac{1}{3}$ of the quantity of lac employed. This dried fecula is to be dissolved or diffused in warm water, and some solution of tin is to be added to it; by which it acquires a vivid scarlet color. This liquor is to be added to a solution of tartar in boiling water; and thus the dye is prepared.

(*f*) LAPIS LAZULI is a blue stone, generally intermixed with white veins and gold-colored spots. Wallerius considers this stone as a species of jasper; and Cronstedt, more justly, as a species of that order of earths which have been lately called zeolites. *See* ZEOLITES. Mr. Margraaf, and also Mr. Cronstedt, have made experiments on this stone, carefully cleansed from all white, pyritous, or heterogeneous matters. From these experiments we learn, 1. That this stone is soluble in acids without effervescence; and when it has been previously calcined, it forms gelatinous masses with acids. 2. That by calcination it is not deprived of its blue color, till at least that operation has been long continued. 3. By a violent fire it is fusible, and forms a frothy glass, sometimes whitish, and sometimes of a dusky yellow color, but always clouded with blue spots. 4. Fused with nitre, and thrown red-hot into [illegible], it tinged the water with a blue colo[illegible]ich disappeared in some hours. By this operation the stone lost its blue color. 5. Some of this stone, powdered and mixed with glass frit, produced a transparent c[illegible] glass. With borax, it produced a [illegible] a chrysolite-color. 6. It gave no [illegible] its containing copper, notwit[illegible] has been considered as an ore of copper by most authors. 7. It shewed marks of iron, by forming a blue precipitate, like Prussian blue, when a phlogisticated alkali was added to a solution of this stone in acids. 8. Margraaf says, that by adding vitriolic acid to solutions of this stone in nitrous and marine acids, a white precipitate was formed, which he supposes was calcareous earth. Nevertheless, Mr. Cronstedt affirms, that this stone does not effervesce with acids. Perhaps the calcareous earth was not essential, but only accidental. 9. Cronstedt says, that a precipitate is formed by adding a fixed alkali to a solution of this stone in vitriolic acid, which, being scorified with borax, yields a regulus of silver. He says, that by scorification with lead, two ounces of silver have been obtained from a hundred pounds of the stone. Mr. Margraaf does not mention that he found any silver, or that he searched for any. Perhaps it is only accidental.

The fine blue substance called *ultramarine* is prepared from lapis lazuli in the following manner, according to Wallerius. The stone, first finely levigated and mixed with linseed oil, is to be added to a paste, made by mixing together equal parts of yellow wax, colophony, pitch, that is, half a pound of each, with half an ounce of linseed oil, two ounces of turpentine, and two ounces of mastic. To three or four parts of this paste one part of the levigated stone, mixed with linseed-oil, is to be added; and after the mixture has been digested together during three or four weeks, it is to be thrown into hot-water, and stirred till the blue color separates and diffuses in the water, which is then to be poured off. The blue matter is allowed to settle; and, when dry, is the ultramarine required.

Like all imperfect metals, it has its peculiar smell and taste. When it is cut by a very sharp instrument, its surface appears smooth, compact, and shining; but it quickly tarnishes in the air, and its surface becomes covered by a slight greyish rust. It resists nevertheless much longer than iron or copper the combined action of air and water, before it is decomposed and destroyed. It is very fusible, and melts nearly with the same degree of heat as tin; that is, before it is red.

As soon as it melts, even with the least heat that is requisite, it calcines; and upon its surface greyish ashes are formed, in the same manner as tin is calcined.

The color, softness, fusibility and calcinability of lead being similar to these qualities in tin, persons acquainted with only the common and superficial qualities of metals suppose that a great analogy subsists between lead and tin; nevertheless, we shall show that the properties of these two metals are essentially different.

The grey calx, or ashes of lead, similar externally to those of tin, become of a very different appearance, if the calcination with a fire so moderate that it cannot melt them be continued, and particularly if they be exposed to flame. Instead of becoming more and more white, they acquire at first a yellow color, and are then called *massicot*, or *yellow lead*. The color becomes more and more intense, and at last entirely red. It is then called *minium*, or *red lead*; *which see*. If instead of calcining this calx with a gentle fire, it be fused, it then easily melts into a yellow vitrified substance, composed of small scales like those of talk. Lead in this state is called *litharge*; *see* that word. This happens in the operation of *cupellation*. Lastly, if calx of lead be heated more than is necessary to keep it in fusion, it then soon changes into a true glass, which becomes so active and fluid, that it passes like water through the most compact crucibles. Lead thus calcined and melted is called *glass of lead*, because in fact it has the transparency, brittleness, and all the essential properties of glass. It is very useful in many arts, as may be seen under the article Glass *of* Lead.

Of all the metallic calxes, that of lead is the most fusible, and most easily convertible into glass; in which respect it differs essentially from the calx of tin, which is very refractory.

This difference proceeds from the total privation which tin sustains of all its phlogiston, and from its capacity of a radical or perfect calcination. Whereas lead, although it loses, as easily as tin does, as much of its phlogiston as is necessary to destroy its metallic appearance, and to calcine or vitrify it; yet it retains enough of its phlogiston to preserve a great fusibility, and even a considerable density: For all the calxes and glasses of lead are very heavy.

All these calxes and glasses of lead are easily revivable. They can scarcely be melted but some part of the lead is revived, although no inflammable matter has been added. This also is a proof that they retain much phlogiston. For, in general, all metallic calxes are so much more easily reducible as they retain more of their inflammable principle.

Lead is soluble by all acids, and presents with them phenomena similar to those of silver with the same acids. Lead combined to saturation with nitrous acid forms, as silver does, a crystallizable nitrous salt with metallic base, called

called *nitre of lead.* This salt is capable of decrepitating, and even of detonating without addition of inflammable matter, as several chemists pretend. This detonation must therefore proceed from the phlogiston retained by the lead, which is sufficiently combustible for that purpose. Kunkel, who seems not to have known this property of nitre of lead, relates, in his Treatise on the Art of making Glass, that when he attempted to distil this salt, his retort was suddenly burst with great noise and danger.

Several chemists, among others Becker in his Second Supplement to the *Physica Subterranea*, and Kunkel in his *Laboratorium Chemicum*, give processes by which mercury may be obtained from lead. Mr. Grosse, who mentions these processes in the Memoirs of the Academy, gives one himself, which is more simple and more easily tried, since it consists only in saturating perfectly some good nitrous acid with lead. By means of this saturation a grey powder is precipitated, according to this chemist, in which mercury is found. But this process probably does not succeed with every kind of lead; for Messrs. Macquer and Beaumé say, in their Course of Chemistry, that they have repeated with all possible attention this experiment of Mr. Grosse, without having obtained mercury.

Pure vitriolic acid, and that contained in neutral vitriolic salts, when mixed with a solution of lead in nitrous acid, unites with the lead, separates it from the nitrous acid, and forms with it a metallic salt, or vitriol of lead, which crystallizes, and appears therefore in form of a white precipitate, when the liquors do not contain a sufficient quantity of water to dissolve it. This salt is the same as that made by dissolving directly lead in vitriolic acid.

Marine acid, and all the neutral salts containing it, precipitate also lead from its solution in nitrous acid, and unite with it, forming a metallic salt called *plumbum corneum*, from the many resemblances that it has with the combination of silver with marine acid, called *luna cornea*. Plumbum corneum differs from luna cornea in being much more soluble in water, which shews an abundancy of marine acid, or that it is less intimately combined in the lead than in the luna cornea. Plumbum corneum may be made by several other methods, and particularly by disengaging the volatile alkali from sal ammoniac by lead; for, like all other metals, it has the property of decomposing this salt. By this method, Mr. Margraaf makes the plumbum corneum which he employs in the preparation of phosphorus.

Several chemists affirm that the solution of lead in nitrous acid may be decomposed by water singly, and that a magistery of lead may be thus formed, in the same manner as that of bismuth. But Mr. Beaumé, who has examined the affair with greater accuracy, found that this precipitation does not happen when very pure, that is, distilled water is used; and that consequently this precipitation is to be attributed to the salts, and particularly to the selenites, contained in almost all ordinary waters.

Vegetable acids also dissolve lead with ease; but only the combinations of this metal with vinegar are known, because these are used in medicine and in the arts. The first of these preparations is called *ceruss*, or *white-lead*. It is a kind of rust of lead, of an admirable white color, made by the acid of vinegar, to the vapor of which the lead is exposed. The chief use of this preparation is for painting in oil; and is the only white hitherto discovered for that purpose,

although

although it has two very great faults. The firſt is, that it gives painful colics to perſons employed in its preparation; and the ſecond is, that it is liable to become yellow or black, and, in a word, to loſe much of its beauty in time; which proceeds from the diſpoſition which this calx of lead, like all the other preparations of this metal, has to recover its phlogiſton, and conſequently its color. The diſcovery therefore of another white, poſſeſſed of the beauty and other advantages of white-lead, without its inconveniencies, would be of important ſervice to painting, and even to mankind. *See* CERUSS.

Ceruſs contains too little of the acid of vinegar to be in the ſtate of a neutral ſalt; but as it is lead much opened and divided, it may be eaſily completely combined to ſaturation with this acid. For this purpoſe ceruſs muſt be digeſted with a ſufficient quantity of diſtilled vinegar, to diſſolve it perfectly. The liquor after this ſolution is called *vinegar of lead*. If it be filtrated, evaporated, and cryſtallized, fine cryſtals are formed, capable of a perfect ſolution in water, of a ſaline, metallic, and ſaccharine taſte, from which this ſalt is called *ſugar* or *ſalt of lead*. Salt of lead may be decompoſed merely by the action of fire. By diſtillation a very concentrated acid of vinegar may be obtained from it, a kind of radical vinegar, ſimilar to that obtained from cryſtals of copper. *See* SALT *of* LEAD.

Oils and fat matters, which in general are capable of acting upon metallic ſubſtances, have a diſtinguiſhed action upon lead, and particularly upon its calxes. In conſequence of this action, ceruſs, minium, and litharge, may be entirely and copiouſly diſſolved in moſt oils by coction with moderate heat. Oils in which lead has been diſſolved are thereby rendered thick and drying. Linſeed oil thus thickened by lead is much uſed in painting. The painters call it *drying oil*. So large a quantity of calx of lead may be diſſolved in oils, that a body is thence formed, which when cold is ſolid, tenacious, and of the conſiſtence of plaſters. The conſiſtence of many of the plaſters uſed in ſurgery is cauſed by calxes of lead diſſolved in oils. Theſe maſſes of lead combined with oil, or plaſters, reſemble ſoap in ſmell, rancid taſte, milkineſs given to water, and laſtly, in being decompoſed by acids which unite with the lead, and ſeparate the oil from it. Theſe obſervations were made by Mr. Geoffroy.

Lead is eaſily united to ſulphur, and is eaſily burnt and calcined by expoſing it at once to the action of ſulphur, fire, and air. With ſulphur alone it forms a compound reſembling the ore of lead, or lead naturally mineralized by ſulphur.

This metal eaſily unites with all metals excepting iron, with which it cannot by any means be allayed. Such is the antipathy of theſe two metals, that if ſilver allayed with ſome iron be melted with lead, the lead preſently ſeizes the ſilver, and the iron floats upon the ſurface of the melted metals. Nevertheleſs the calxes of lead and iron are very well united together by fuſion, and the former facilitates the vitrification of the latter as much as it does that of the calxes of other metals. Hence lead may be employed to purify the perfect metals from iron, as well as from other imperfect metals. Of all the allays of lead, that with tin is moſt uſed, being employed for ſoldering by plumbers, and for tinning. If an allay of lead and tin be expoſed to an open fire, ſufficiently ſtrong to make the metal red-hot and to ſmoke, theſe two metals will burn and calcine together

much

much more quickly and perfectly than either of them would do singly. The calx resulting from this operation is the basis of white enamels, and glazings for earthen ware. It is called *putty*.

The affinities of lead, according to Mr. Geoffroy's table, are silver and copper: according to Mr. Gellert's table, they are silver, gold, tin, copper. Iron is marked in this table as being incapable of uniting with lead.

*Lead and its several preparations are of great use. It is used and formed into sheets and pipes, for containing and conducting water in buildings and gardens. Lead is not much used in medicine, only externally, from the colics and palsies which it occasions when taken internally. But its external applications are very useful, from its sedative, drying, and repelling qualities. The vinegar and the sugar of lead, also all the ointments and plasters which contain cerus, minium, or litharge, eminently possess these qualities. We have seen that lead is much employed in painting with oil, both as a color and as a dryer. It is also used in the preparation of enamels and of porcelain as a flux, and makes the basis of the glazing of almost all pottery wares from the most ordinary kind to the finest. Lastly, by means of lead, the most perfect metals are refined and essayed. We may therefore say, that this metal is so generally used, and so necessary in the important arts we have mentioned, that they absolutely could not exist without it.

CCCCXI. L E A T H E R (F O S S I L). (g)

CCCCXII. L E A V E S. (h)

(g) Leather (Fossil). *Aluta montana*. This is a foliated amianthus, consisting of soft fibres interwoven together. Frequently it contains sparry crystals enclosed in it. For the properties of this stone, *see* Amianthus.

(h) Leaves. The following remarks concerning the coloring substance of leaves are taken from Dr. Lewis. The green color of the leaves of plants may be extracted by rectified spirit of wine and by oils. The spirituous tinctures are generally of a fine deep green, even when the leaves themselves are dull colored, or yellowish, or hoary. The color however seldom remains long in these liquors; and it remains a much shorter time when the coloring matter is separated in a solid form, and exposed to air. The *mercurialis* gives a more durable green color to spirit than any other herb. Alkalis heighten the colors of the tinctures and of the juices; and acids weaken, destroy, or change them to a yellowish color. Alum-water improves the color, and also the durability of the color. By means of lime, not inelegant green lakes may be obtained from the leaves of [illegible], *lily of the valley*, and of several other plants. Few herbs communicate any part of their green color to water; perhaps none give a green considerably deep. Nevertheless a green dye is said to be given to woolen by the leaves of some plants, as of the wild *chervil*, or *cow-weed*, the common *rag-wort*, and *devil's-bit*. The leaves of many kinds of herbs and trees give a yellow dye to wool, previously boiled in a solution of alum and tartar. *Weld* particularly affords a fine yellow dye. Mr. Hellot observes, that all leaves, barks, and roots, which have an astringent taste, as the leaves of the *almond*, *peach*, and *pear* trees, ash-bark, roots of *wild patience*, &c. yield durable yellows. From the leaves of two plants, *blue* coloring substances are produced, namely, *indigo* and *woad*; which *see*. Mr. Hellot suspects that a similar blue fecula might be produced from many other vegetables. He supposes the green color of vegetables to proceed from a mixture of blue and yellow particles, and that the former are frequently more permanent than the latter, so as to be capable of resisting the fermentation of the juice of the plants, while the yellow are destroyed by that fermentation. Dr. Lewis has tryed, without success, to obtain blue dyes from other plants, by putrefying them in water.

CCCCXIII.

CCCCXIII. LEY (CAUSTIC), *or the* LEY *of* SOAP-BOILERS. This name is given to lixiviums of fixed alkali rendered cauſtic by quicklime. To make theſe leys, two parts of ſoda or of potaſh are mixed with one part of quicklime; or equal parts of alkaline ſalt ready prepared and quicklime are added together. This mixture is to be put into a large veſſel, and 12 or 15 times as much pure water is to be poured upon it, and the quicklime is to be thus ſlaked: after which the whole is to be boiled during ſome minutes, and the ley while yet hot is to be filtered through a brown paper filter ſupported upon linen, and the ley is to be concentrated by evaporation upon the fire, to ſuch a degree as is judged neceſſary, according to the uſe for which it is deſigned.

Quicklime has the property of encreaſing conſiderably the cauſticity of all fixed alkalis; and this is probably done, not only by taking from them their ſuperabundant inflammable matter, but a part alſo of that which enters into their compoſition as a principle. Hence a conſiderable alteration is produced upon theſe alkalis by quicklime, ſimilar to that produced upon volatile alkali, and we may conſequently decompoſe entirely all alkalis by quicklime. But theſe experiments have not been hitherto proſecuted. The properties of fixed alkali rendered cauſtic have not been ſufficiently examined. We know only that by this treatment the diſſolving power of alkalis, and particularly upon oily matters, is much encreaſed; and they are therefore thus prepared, when they are to be combined with oils for the formation of ſoaps. (*i*)

The cauſtic ley, evaporated to dryneſs, furniſhes an alkaline ſalt exceedingly acrid, which being melted in a crucible becomes what is called *common cauſtic*; becauſe when it is applied to the ſkin, it makes an eſchar, pierces it, and leaves an ulcer, the ſuppuration of which, when continued, is called an *iſſue*.

Cauſtic alkali has not only much greater diſſolving power, but it is alſo much more deliqueſcent, and attracts much more powerfully the moiſture of the air, than ordinary alkali. Theſe properties muſt proceed from the developement of the ſaline principle by the quicklime. *See* ALKALI.

CCCCXIV. LILLY *of* PARACELSUS. *See* TINCTURE *of* METALS.

CCCCXV. LINNEN (FOSSIL.) (*k*)

CCCCXVI. LIQUOR SILICUM. LIQUOR *of* FLINTS. The preparation of this liquor conſiſts in uniting by fuſion powdered flints or ſand with a ſufficient quantity of fixed alkali, ſo that a compound reſults from it in which the properties of the alkali prevail, and particularly a total ſolubility in water. For this purpoſe one part of ground flints or ſand is to be well mixed with three or four parts of fixed alkali. The mixture is to be put into a crucible which ought to be very large, in proportion to the quantity of matter. The crucible is then to be placed in a forge or good melting furnace, and gradually heated.

When this mixture has acquired a certain heat, a conſiderable boiling and ſwelling are obſervable, occaſioned by the action of theſe two matters upon

(*i*) The effect produced upon alkalis by quicklime is the abſorption of their fixable air. *See* AIR (FIXABLE) *and* ALKALI.

(*k*) LINNEN (FOSSIL). Is a kind of *amianthus* which conſiſts of flexible, parallel, ſoft fibres, and which has been celebrated for the uſe it has been applied to, of being woven, and forming an *incombuſtible cloth*. Paper has alſo been made of it, and wicks for lamps. *See* AMIANTHUS.

each

each other. To prevent the matter in this ſtate from flowing over the crucible, this ought to be large, and the fire gradually raiſed. A part only of the mixture may be put into the crucible at once; and when its effervefcence is over, the reſt may be added at different times, taking care that each portion to be added be previouſly heated, to prevent explosion from any moiſture which it might contain, when mixed with red-hot melted matter.

When the effervefcence of all the mixture is over, it is to be kept in a good fuſion during a quarter of an hour, and is then to be poured upon a greaſed ſtone or plate of iron. The matter when cold is brittle, and ſeems vitrified. It is even tranſparent like glaſs, when the quantity of alkali is only double or nearly double the quantity of flints. It quickly and ſtrongly attracts moiſture from the air, and is entirely ſoluble in water, except a very ſmall portion of earthy matter. But a ſimilar earth is alſo always ſeparated from pure fixed alkali during its ſolution in water.

The filtrated ſolution is at firſt clear, and limpid; but it afterwards becomes turbid, and forms an earthy ſediment, like that formed by ſolutions of fixed alkali, only the former ſeems more copious. This liquor has all the properties of liquid fixed alkali.

All theſe properties of alkaline ſalts, and particularly its total ſolubility in water, are cauſed by the quantity of fixed alkali which enters into this kind of vitrified matter. As compound bodies partake always of the properties of their component principles, and as the properties of the principle which predominates in the compoſition of any body do alſo predominate in that body, we may perceive why the properties of the fixed alkali in the preſent combination ſhould be more ſenſible than thoſe of the earthy matter or flints. The alkali communicates to the earthy matter ſome of its ſtrong diſpoſition to unite with water. The flints are really kept diſſolved in water, and by this experiment they are conſequently reduced into a liquor, and hence it has been called the *liquor of flints.* If any acid be added to the liquor of flints ſo as to ſaturate the alkali, the flint which was kept diſſolved in water by means of this alkali will be now precipitated in ſtate of a fine earth. Mr. Pott mentions a very ſingular phenomenon which happens in this experiment, which is, that this earthy precipitate is entirely ſoluble by acids; ſo that if more acid be added than is ſufficient to ſaturate the alkali, the precipitate will entirely diſappear.

As vitrifiable earths in their natural ſtate, and even when divided as much as is poſſible by mechanical methods, are inſoluble in acids, and as they become ſoluble by acids, when they have been combined by fuſion with a ſufficient quantity of fixed alkali, they muſt conſequently undergo a ſingular alteration in this operation. This property which they acquire of diſſolving in acids, proceeds either from the great fineneſs to which their parts are reduced, or from a ſmall portion of fixed alkali, or from ſome of its principles which remain united with them, and from which they cannot be entirely ſeparated by the precipitating acid.

The fixed alkali which enters into this combination receives alſo ſome alteration from the vitrifiable earth; one part of it is decompoſed, and its earth is precipitated with the vitrifiable earth, and the remaining part is rendered much more cauſtic than it was before.

In vitrifications ſomething happens ſimilar to what is obſerved in the compound deſigned to make the liquor of flints. The glaſſes which contain too

much alkaline ſalt in their compoſition, or which have not ſuſtained a long or ſtrong enough fire to unite the earth intimately with the fixed alkali, are partly ſoluble in acids, have ſometimes even an alkaline taſte, tarniſh, and moiſten in the air. *See* VITRIFICATION.

CCCCXVI. LIQUOR, *or* SPIRIT (SMOKING) *of* LIBAVIUS. This preparation is a marine acid very concentrated, ſmoking, and impregnated with much tin. It is obtained by diſtillation from a mixture of corroſive ſublimate with tin.

To make the ſmoking liquor of Libavius, an amalgam muſt be made of four parts of tin and five parts of mercury: this amalgam is to be well mixed with an equal weight of corroſive ſublimate, by triturating the whole together in a glaſs mortar. This mixture is to be put into a glaſs retort, which is to be placed in a reverberatory furnace. To the retort is to be luted with fat lute a receiver with a ſmall hole in it, in the ſame manner as is done for the diſtillation of concentrated mineral acids. The diſtillation is then to be begun with a graduated and well managed fire. A very ſmoking liquor paſſes into the receiver, and towards the end of the diſtillation a very thick and even concrete matter. When the operation is finiſhed, the liquor in the receiver is to be poured quickly into a cryſtal glaſs bottle with a glaſs ſtopper. When this bottle is opened, a white, copious, thick, and poignant fume iſſues, which remains long in the air without diſappearing.

The very concentrated marine acid contained in the corroſive ſublimate quits the mercury in this experiment to unite with the tin; and as this acid has the property of raiſing with it in diſtillation moſt metallic matters, a conſiderable quantity of the tin paſſes over in this diſtillation. Nevertheleſs this acid is far from being ſaturated with tin; it is ſtill very acid, and capable of diſſolving much tin in the ordinary way. From this imperfect ſaturation, together with its great concentration, proceeds partly its property of ſmoking ſo conſiderably. Nevertheleſs ſome other cauſe probably concurs to give it this property. For although this liquor ſmokes infinitely more than the moſt concentrated ſpirit of ſalt, diſtilled in Glauber's manner, its vapors are notwithſtanding much leſs elaſtic. Another very eſſencial difference betwixt this liquor and concentrated ſpirit of ſalt is, that by mixing the former, but not the latter, with ſpirit of wine, marine ether may be obtained. *See* ETHER (MARINE).

Laſtly, if we attempt to diſſolve, by the ordinary method, as much tin in concentrated ſpirit of ſalt as is contained in the ſmoking liquor of Libavius, this acid, ſo far from being thereby rendered more ſmoking, ceaſes entirely to ſmoke. A real difference therefore ſubſiſts betwixt the marine acid impregnated with tin by the decompoſition of corroſive ſublimate, and by diſtillation, and the marine acid treated with tin in any other manner. But we cannot eaſily determine whence this difference proceeds. Does this acid depoſit in the mercury or in the tin ſome of its principles? If that be the caſe, with what principle is tin impregnated in this experiment? Is it with phlogiſton? or with mercurial earth? Theſe queſtions cannot be decided without further reſearches.

The ſmoking liquor has all the other properties of the moſt concentrated marine acid, when imperfectly ſaturated with tin. If it be diluted with much water, moſt of its tin will be ſeparated from it in the form of white light flakes,

when it is mixed with a ſolution of gold in aqua regia, it forms the purple precipitate of Caſſius, as all other ſolutions of tin, and even pure tin not diſſolved, do. *See* PRECIPITATE (PURPLE) *of* CASSIUS. It may be precipitated by abſorbent earths, and by alkaline ſalts. In ſeveral dyes, particularly in thoſe which are red, it produces the ſame effects as tin diſſolved by marine acid. *See* DYEING.

The neceſſary management for making the ſmoking ſpirit of Libavius is not very troubleſome or difficult. This operation is much eaſier than the diſtillation of very ſmoking ſpirit of ſalt by means of vitriolic acid, from the greater elaſticity and expanſive force of the vapors of the latter.

For the diſtillation of the ſmoking ſpirit of Libavius, the tin is previouſly amalgamated with mercury, becauſe in this ſtate it is much more eaſily miſcible with corroſive ſublimate. If the diſtillation be continued, and the heat encreaſed, after the butter of tin, or the concrete part of the combination of tin with marine acid, has riſen, the mercury revived from the corroſive ſublimate may be obtained. *See* ACID (MARINE), TIN, MERCURY, *and* CORROSIVE SUBLIMATE.

CCCCXVII. LIQUOR (MINERAL ANODYNE) *of* HOFFMAN. This compoſition, which is uſed in medicine only, is a mixture of very rectified ſpirit of wine, of ether, and of a little of the ſweet oil of vitriol. This liquor is made by mixing an ounce of the ſpirit of wine which riſes firſt in the diſtillation of ether, with as much of the liquor, and afterwards by diſſolving in this mixture, which riſes next, and which contains the ether, twelve drops of the oil which riſes after the ether has paſſed. This is what is called the mineral anodyne liquor of Hoffman. It has preciſely the ſame virtues as the ether, which phyſicians now begin to ſubſtitute for it. As ether and oil of ſpirit of wine is now made from the nitrous, marine, and acetous acids, liquors may be made from theſe, in imitation of that of Hoffman from the vitriolic acid. *See* ETHERS.

CCCCXVIII. LITHARGE. Litharge is lead deprived of great part of its phlogiſton by fire, and is in a ſtate of imperfect vitrification.

When ſilver is refined by cupellation with lead, this latter metal, which is ſcorified, and cauſes the ſcorification of the imperfect metals allayed with the ſilver, is transformed into a matter compoſed of ſmall ſemi-tranſparent ſhining plates, reſembling mica; which is litharge. Litharge is more or leſs white or red, according to the metals with which the ſilver was allayed. The white is called *litharge of ſilver*, and the red is called *litharge of gold*.

Litharge may be eaſily revived into lead; accordingly much of that which is produced by refining in great is reduced, by being melted upon burning coals. The part of it which is leaſt altered by mixture with other metals is thus reduced, and by this method good and ſaleable lead is obtained. The reſt of the litharge of theſe refineries is ſold and uſed for various purp[illegible] Potters uſe much of it for glazing their ware. It is employed for the [illegible]tion of ſome plaſters, and other external remedies; and alſo in painting, [illegible]der linſeed oil drying. Laſtly, it is added in the compoſition of [illegible] glaſſes, for it is very fuſible, and aſſiſts the fuſion of other ſubſtances. It has in general the ſame properties as the other calxes of lead. All the litharge which is commonly ſold comes from refineries. The quantity formed there is more than

is sufficient for the demand, and therefore it is not prepared purposely. *See* REFINING *and* LEAD.

CCCCXIX. LIVER *of* ANTIMONY. Liver of antimony results from the detonation of antimony with an equal weight of nitre. These two matters reduced into powder are to be mixed together, and put into a large crucible. The matter is then to be kindled, and the detonation to be made. When it has detonated, it is to be kept in fusion and then cooled. When the crucible is broken, at the bottom two distinct matters are found, which may be separated from each other by the stroke of a hammer. The upper matter is a saline scoria, nearly of the same nature as the scoria of the regulus of antimony. This is a true antimoniated liver of sulphur, mixed with a certain quantity of vitriolated tartar. The lower matter is heavier. It is opake, compact, red, and brittle. This is the liver of antimony. Its color and appearance have been supposed similar to those of the livers of animals, and thence it has received its name.

Liver of antimony is principally composed of the metallic part of antimony, half deprived of its sulphur, and dephlogisticated by nitre.

Some chemists consider the liver of antimony as an antimoniated liver of sulphur. Others affirm, that it is only the metallic earth of antimony, melted, by means of a remaining part of sulphur and phlogiston, into a substance the nature of which is intermediate betwixt those of antimony and of glass of antimony. It may possibly be sometimes in one state, and sometimes in the other, according as the matter has been more or less long in the fire, and more or less well fused. The true nature of this substance may easily be ascertained by a proper examination. But this preparation, which was considered as important when antimonial remedies were first introduced, deserves at present little notice. For it is not of any use in what is properly called Chemistry; and it is no longer employed in Medicine, since kermes mineral and emetic tartar have been introduced, which are remedies superior to all other antimonials from the certainty of their effects, when they are well prepared, and by which all the effects obtainable by any preparation of antimony may be obtained, by giving them separately or conjunctly in different proportions, according to the indications to be answered. *See* ANTIMONY, KERMES MINERAL, *and* TARTAR (EMETIC).

CCCCXX. LIVER *of* ARSENIC. Liver of arsenic is a combination of white arsenic with liquid fixed vegetable alkali, or by the humid way. Arsenic has in general a strong disposition to unite with alkalis. Mr. Macquer, in his Memoirs upon Arsenic, mentions a singular kind of neutral salt, which results from the union of arsenic with the alkaline basis of nitre, when nitre is decomposed, and its acid is disengaged in close vessels, by means of arsenic. To this salt he has given the name of *neutral arsenical salt*. See that article. The liver of arsenic mentioned also by that chemist, although composed, like the neutral arsenical salt, of arsenic and fixed alkali, is nevertheless very different from that.

The operation for making liver of arsenic is easy and simple. To strong and concentrated liquid fixed alkali, previously heated, fine powder of white arsenic must be added. This arsenic easily disappears and dissolves, and as much of it is to be added till the alkali is saturated, or has lost its alkaline properties,

although

although it is still capable of dissolving more arsenic superabundantly. While the alkali dissolves the arsenic in this operation, it acquires a brownish color, and a singular and disagreeable smell, which however is not the smell of pure arsenic heated and volatilised. Lastly, this mixture becomes more and more thick, and at length of a gluey consistence. This matter is not crystallizable as the neutral arsenical salt is. It is easily decomposed by the action of fire, which separates the arsenic. This does not happen to the arsenical salt. Lastly, any pure acid is capable of separating arsenic from the liver of arsenic, in the same manner as they separate sulphur from liver of sulphur: whereas the neutral arsenical salt cannot be decomposed but by means of the united affinities of acids and metallic substances. Thus we see that arsenic may be combined with fixed alkali in two very different manners.

The author has given to this combination the name of *liver of arsenic*, to distinguish it from the neutral arsenical salt, and in imitation of the name of the *liver of sulphur*, given to the combination of the fixed alkali with sulphur. *See* ARSENIC *and* NEUTRAL ARSENICAL SALT.

CCCCXXI. LIVER *of* SULPHUR. The liver of sulphur is the combination of sulphur with alkaline matters. Ordinary liver of sulphur, or the combination of sulphur with fixed alkali, may be made either in the dry or humid way.

To make liver of sulphur by the dry way, or by fusion, equal parts of fixed alkali and sulphur are mixed together. This mixture is to be put into a crucible, and it is to be quickly fused to avoid the dissipation and combustion of the sulphur. A strong heat, however, is not necessary; because the sulphur easily melts and facilitates the fusion of the alkali. When this mixture is perfectly fused, it is to be poured upon a greased stone, and then the liver of sulphur congeals and acquires a brown color. If it be required to be kept dry, it must be quickly broken in pieces, and put while it is yet hot into a bottle which is to be well corked, because it readily imbibes moisture from the air.

To make liver of sulphur in the humid way, concentrated liquid fixed alkali and fine powder of sulphur are to be boiled together, till the alkali has dissolved all that it can: the liquor is then to be filtrated and evaporated. This second method of making liver of sulphur is not much used, because it is longer and less advantageous than the former.

Liver of sulphur is an important combination in chemistry, because it is in general a very powerful solvent. This compound partakes, according to the general rule, of the properties of the two substances which enter into its combination. The sulphur, by its union with the alkali, appears less volatile, less combustible than when alone, and may be entirely dissolved in water by the intervention of this alkali; and also this alkali, saturated with sulphur, shews less of its alkaline properties.

As sulphur is composed of vitriolic acid and phlogiston, we may doubt to which of these its union with the fixed alkali is to be attributed. But if we attend to the properties of liver of sulphur, we shall perceive that the sulphur is in all its substance combined with the alkali, and adheres to it by both its principles. In fact, if we dissolve liver of sulphur in water, and pour into this solution any acid, the liver of sulphur will be instantly decomposed by this acid, which will unite with the alkali, and separate from it the sulphur in form of a

white

white powder: but this powder, when dried and examined, appears to be sulphur, such as it was before.

Although vitriolic acid which is contained in sulphur be in general the strongest acid, the sulphur is nevertheless separated from the alkali by any acid, even by the weakest, as vinegar. This phenomenon is another proof of what we have advanced concerning the manner in which sulphur is combined with alkali; for if the union of the inflammable principle of the sulphur did not considerably oppose the adhesion which the acid of this sulphur is capable of contracting with fixed alkali, the weaker acids certainly could not separate it. These effects may be explained by this general principle, that the less simple any bodies are, the less strongly they are capable of adhering to other bodies.

The liver of sulphur exhibits also another phenomenon worthy of attention, and which depends also, as we shall see, on the same principle. It is, that the connexion betwixt the phlogiston and the acid is much less in sulphur united to an alkali than in pure sulphur. This is proved by the smell of the liver of sulphur, which is very strong and very fetid, even when it is not heated; while sulphur, not heated, has scarcely any smell.

This smell of the liver of sulphur, which resembles much the smell of eggs beginning to putrify, becomes much stronger when it is decomposed by an acid. It is certainly occasioned by an evaporation of part of the phlogiston of the sulphur; for it produces exactly all the effects of the inflammable principle when reduced into vapor, or when it disengages itself from bodies without burning. It particularly affects the brain and nervous system, and causes stupefaction, intoxication, syncopes, and when in large quantity is even capable of instantly killing men and animals. These are the same effects which are produced by the vapors of charcoal, and of substances undergoing the spirituous or putrid fermentations. Mr. Cartheuser, talking of the manner of decomposing sulphur with an alkali, to obtain from it the acid without sensible combustion, according to Stahl's process, expressly remarks, that the vapor which exhales during this operation affects the head, and causes stupefaction. I know a chemist who, when he was decomposing at once a large quantity of liver of sulphur by an acid, was struck by the vapor so as to fall down and faint.

Further, the emanations of liver of sulphur, which are nothing else than pure phlogiston reduced into vapor, and which must be distinguished from the vapor of burning sulphur, which is dephlogisticated vitriolic acid; these emanations, I say, of liver of sulphur are easily applied to any body capable of receiving the inflammable principle, and combine more or less intimately with these bodies, according to their nature and actual state. If silver, for example, be exposed to the vapor of liver of sulphur, or if it be immersed in a heated solution of liver of sulphur, the surface of this metal becomes tarnished and blackened by the phlogistic emanations, with which it readily is impregnated superabundantly. Also, if solutions of silver, mercury, lead, or bismuth, be precipitated by liver of sulphur, all these precipitates, instead of being white, as they would have been if a pure alkali had been used, are rendered brown, black, or leaden-colored, by the phlogiston which attaches itself to them: hence solutions of these metals become sympathetic inks, which may be rendered visible by liver of sulphur, or by its vapor; and hence liver of sulphur may be successfully employed to discover lead contained in adulterated

wine;

wine; and reciprocally, these metals, their solutions or calxes, may be properly applied to discover sulphur in mineral waters or other liquors. *See* INK (SYMPATHETIC), WATERS (MINERAL), *and* WINE.

We must observe, that in this application of the phlogiston of liver of sulphur to most metallic calxes, this phlogiston, although transmitted either in vapor, or by the humid way without fusion, combines nevertheless so intimately with these metallic earths as to revive them, and to restore to them all their metallic properties. This truth, though long ago known to chemists, was alluded to by Mr. Rouelle the younger, who, in the Medical Gazette, proposes this reduction in form of a problem, as a very great novelty. The chemist who replied, judiciously used litharge to make this reduction visible; because this preparation of lead being in molecules or scales, which present surfaces very smooth and sufficiently large, is very proper to shew the metallic color and brilliancy which the litharge instantly assumes, when it is immersed even in a cold solution of liver of sulphur. *See* REDUCTION.

All these properties of liver of sulphur shew very clearly, that the adhesion of the phlogiston to the acid in sulphur is greatly diminished by the union of sulphur with alkali; and as the phlogiston is infinitely more volatile than the acid, it may therefore be more easily separated from the liver of sulphur. The smell and emanations of liver of sulphur shew, that its inflammable principle is continually dissipating. We may therefore consider sulphur, formed into liver of sulphur, as gradually decomposing, particularly when it is dissolved in water. Accordingly, if we preserve liquid liver of sulphur in an open vessel, the quantity of sulphur diminishes more and more, and the liver of sulphur gradually changes into vitriolated tartar.

We may form an explanation of this diminution of the connexion of the principles of sulphur in the liver of sulphur, if we suppose that all bodies have only a certain determinate degree of force by which they adhere to each other; which is very probable, and is even shewn by all the phenomena of chemistry; and if we suppose, in the second place, that in sulphur the phlogiston and acid have exhausted upon each other all their force of tendency or of combination. Upon these suppositions, these two principles are either incapable of combining with a third body, as with the alkali; or if they combine with it, this new union must lessen the force of the former union; and this accordingly appears to be the reason why the simplest bodies are those which contract the strongest union. *See* AFFINITY, AGGREGATION, COMBINATION, *and* SOLUTION.

Liver of sulphur is a great solvent of metallic matters; all which, excepting zinc, it attacks, particularly in fusion. It seems to dissolve gold more effectually than other metals. *See* GOLD. This compound dissolves also vegetable coals, even by the humid way, according to the observation of Mr. Rouelle the younger. This solution is of a green color; and when liver of sulphur has dissolved charcoal by fusion, it becomes of a much deeper red color than when pure, as may be observed in the making of artificial sulphur in Stahl's manner.

Particular kinds of liver of sulphur may be formed by the combination of volatile alkali, of quicklime, or of absorbent earths, all which attack sulphur more or less. The properties of these livers of sulphur may be referred to those of the

the ordinary one; but they have not been examined so much as they ought to be. *See* SULPHUR.

CCCCXXII. LIXIVIAL. Those salts are called lixivial which have been extracted by lixiviation, and these chiefly are fixed alkalis; which are therefore called *lixivial salts*. *See* ALKALI.

CCCCXXIII. LUNA CORNEA. This name is given to the combination of marine acid with silver. Marine acid has in general a great affinity with metals, and particularly with those called *white*, or *lunar*, or *mercurial metals*. Of these silver is the chief. Marine acid can scarcely dissolve these metals in the ordinary methods. They must be generally much divided, or the acid must be much concentrated, reduced into vapors, and assisted with a considerable degree of heat, to accomplish the solution. This is particularly true as to silver and mercury. But when these metals are previously dissolved in nitrous acid, then the marine acid, which has a stronger affinity with them than the nitrous has, seizes them quickly, separates them from the nitrous acid, and forms with them a new combination.

To make this combination with silver, it is first dissolved in nitrous acid. To this solution marine acid, or more commonly common salt dissolved in water, is to be added. The mixture soon becomes turbid, and in it a copious precipitate is formed, which has always the appearance of curd. The solution of salt is thus added till no more precipitate is formed. The precipitate, when separated from the supernatant liquor, is called *luna cornea*.

Marine acid has so great an affinity with silver, that it overcharges itself in some measure with the metal in this precipitation. Luna cornea is much less soluble in water than the combinations of other metals with this acid. This little solubility of luna cornea is the cause of its appearing in the form of a precipitate.

The adhesion of the marine acid with silver is very strong in luna cornea. If this matter be exposed alone to fire, the acid carries off with it a portion of the silver, although this metal be very fixed. The remaining matter melts, and takes the form of a horn-like substance, as all chemists say; and hence it has been called luna cornea. Some differences must occur in combining marine acid with silver, according to the manner in which it is done, and particularly according to the proportion of the two substances.

Luna cornea is not employed either in medicine or in the arts (*l*); and is even little used in chemistry, excepting for particular operations and researches. This precipitation is very convenient, for example, in the examination of mineral waters, or of any other liquor, to discover if they contain marine acid in whatever base it be engaged, excepting metallic bases; for if these waters contain the smallest quantity of marine acid, a luna cornea will be precipitated by them

(*l*) Luna cornea mixed with sea-salt and tartar rubbed on brass, gives a silver-like appearance; and is the substance employed for the silvering of the dial-plates for clocks. A more substantial silvering may be given by the above mixture, if the piece of brass to be silvered be previously heated considerably, and cleaned with a scratch-brush, and if the operation be repeated till the silver seems to be sufficiently thick. The brass, having a stronger disposition to unite with the marine acid than the silver has, separates it from this latter metal, which is then precipitated upon the surface of the brass plate.

them from a ſolution of ſilver in nitrous acid, and this luna cornea is eaſily known by its curd-like appearance. *See* WATERS (MINERAL).

We may eaſily perceive that when the marine acid, which forms the luna cornea, is engaged in a baſis, it muſt quit its baſis to combine with the ſilver; and then the nitrous acid, which was united with the ſilver, is now diſengaged, and joins itſelf to the ſubſtance with which the marine acid was firſt united; ſo that two decompoſitions take place, from which two combinations reſult. Thus, when luna cornea is made with a ſolution of common ſalt, the liquor after the operation contains ſome cubic nitre; and if marine ſalt with an earthy baſis was uſed, it would be transformed, in this operation, into a nitre with an earthy baſis.

The beſt method of ſeparating ſilver from marine acid, or, as the chemiſts ſay, of reducing luna cornea, is to mix it very accurately, and to melt it in a crucible, with a very large quantity of ſome fixed alkali: but the heat muſt be very gradually applied till the ebullition and ſwelling, which are cauſed by the action of the fixed alkali and marine acid, have ceaſed; then the heat is to be encreaſed, and the matter is to be thoroughly fuſed; after which, the ſilver is found revived at the bottom of the crucible. This ſilver is juſtly eſteemed to be the pureſt of all, when the ſeveral operations have been well made. But the luna cornea cannot eaſily be reduced without loſs; becauſe it is apt to evaporate partly, and even to paſs through crucibles. *See* ACID (MARINE), *and* SILVER *.

CCCCXXIV. LUTE. In many chemical operations, the veſſels muſt be covered with ſomething to preſerve them from the violence of the fire, from being broken or melted, and alſo to cloſe exactly their joinings to each other, to retain the ſubſtances which they contain, when they are volatile and reduced to vapor. For this purpoſe, ſeveral matters are employed, called in general *lutes*.

The lutes with which glaſs and earthen-ware retorts are covered ought to be compoſed of nearly equal parts of coarſe ſand and refractory clay. Theſe matters are to be well mixed with water and a little hair, ſo as to form a liquid paſte, with which veſſels are to be covered, layer upon layer, till it is of the required thickneſs.

The ſand mixed with the clay is neceſſary in this lute, to prevent the cracks which are occaſioned by the contracting of clay during its drying, which it always does when it is pure. The hair ſerves alſo to bind the parts of the lute,

* Mr. Margraaf has made experiments to diſcover the beſt method of reducing luna cornea, which he found to be the following: Diſſolve half an ounce of fine ſilver in aqua fortis, precipitate it by ſea-ſalt, and edulcorate the precipitate, which will then weigh five drams and ſixteen grains. For the reduction of this precipitate, mix it with an ounce and a half of dry volatile ſal ammoniac, triturate them well together with a little water during a quarter of an hour; then add three ounces of mercury obtained from cinnabar by means of quicklime, and continue to triturate during ſome hours with a little more water. Thus an amalgam will be formed, which being waſhed from a white powder and dried, will weigh three ounces and half a dram. By diſtillation of this amalgam, a reſiduum of ſilver, four grains leſs than the original half-ounce, will be obtained. By ſubliming the white powder, which weighs five drams, three grains of ſilver will be obtained: but if the amalgam and white powder be together diſtilled, the operation will fail, and the luna cornea be recompoſed. *See* BERLIN MEMOIRS, 1749.

and to keep it applied to the veſſel: for, notwithſtanding the ſand which is introduced into it, ſome cracks are always formed, which occaſion pieces of it to tumble off.

The lutes with which the joinings of veſſel are cloſed, are of different kinds, according to the nature of the operations to be made, and of the ſubſtances to be diſtilled in theſe veſſels.

When vapors of watery liquors, and ſuch as are not corroſive, are to be contained, it is ſufficient to ſurround the joining of the receiver to the noſe of the alembic, or of the retort, with ſlips of paper or of linen, covered with flour-paſte. In ſuch caſes alſo ſlips of wet bladder are very conveniently uſed.

When more penetrating and diſſolving vapors are to be contained, a lute is to be employed of quicklime ſlaked in the air, and beat into a liquid paſte with whites of eggs. This paſte is to be ſpread upon linen ſlips, which is to be applied exactly to the joining of the veſſels. This lute is very convenient, eaſily dries, becomes ſolid, and ſufficiently firm.

Laſtly, when ſaline, acid, and corroſive vapors are to be contained, we muſt then have recourſe to the lute called *fat lute*. This lute is made by forming into a paſte ſome dried clay, finely powdered, ſifted through a ſilken ſearce, and moiſtened with water, and then by beating this paſte well in a mortar with boiled linſeed oil, that is, oil which has been rendered drying by litharge diſſolved in it, and fit for the uſe of painters. This lute eaſily takes and retains the form given to it. It is generally rolled into cylinders of a convenient ſize. Theſe are to be applied, by flattening them, to the joinings of the veſſels, which ought to be perfectly dry, becauſe the leaſt moiſture would prevent the lute from adhering. When the joinings are well cloſed with this fat lute, the whole is to be covered with ſlips of linen ſpread with lute of lime and whites of eggs. Theſe ſlips are to be faſtened with pack-thread. The ſecond lute is neceſſary to keep on the fat lute, becauſe this latter remains ſoft, and does not become ſolid enough to ſtick on alone.

M.

CCCCXXV. MACERATION. Maceration is the ſteeping of bodies in a cold liquor, to ſoften, penetrate, and open them; or even to diſſolve ſome principle of them. This operation is eſſentially the ſame as digeſtion, and only differs in this, that it requires no more than the heat of the atmoſphere. Maceration is preferable to digeſtion, whenever heat is uſeleſs or hurtful to the operation. For inſtance, when hard and woody aromatic vegetable matters are to be ſteeped, with intention to ſoften and open them, to extract afterwards more eaſily from them their eſſential oil, they ought to be macerated without heat, and not digeſted, conſidering that the ſmalleſt heat is capable of diſſipating a great part of the ſpiritus rector, which ought always to be preſerved as much as is poſſible, ſince it ameliorates the eſſential oil, and encreaſes its quantity.

CCCCXXVI. MADDER. *(m)*

CCCCXXVII. MAGISTERY. This name is given to almoſt all precipitates. Thus magiſtery and precipitate are frequently ſynonimous: but lately chemiſts have chiefly uſed the term precipitate, and applied that of magiſtery to ſome particular precipitates only, which are uſed in medicine and in the arts. Such are the magiſteries of biſmuth, coral, crabs-eyes, ſulphur, &c. *See* PRECIPITATION *and* PRECIPITATE.

CCCCXXVIII. MAGISTERY *of* BISMUTH. The magiſtery of biſmuth is the calx of that ſemi-metal, ſeparated from the nitrous acid by water alone, and well waſhed.

To make this preparation, very pure biſmuth muſt be diſſolved in nitrous acid, which muſt alſo be very pure. To this ſolution when a very large quantity of clear water is added, the whole is rendered turbid and milky, and a

(m) MADDER. The root of madder impregnated water with a dull red color, and ſpirit of wine with a deep bright red. This root, when eat by animals along with their food, tinges their urine, and their moſt ſolid bones, of a deep red. Wool, previouſly boiled in a ſolution of alum and tartar, receives from a hot decoction of madder and tartar a very durable, but not a very beautiful red color.

very beautiful and ſhining white ſediment is afterwards formed. The ſupernatant liquor is then to be decanted; the ſediment is to be put upon a paper filter, and more pure water is to be added, till it comes off quite inſipid. The ſediment, which is the magiſtery of biſmuth, ought to be carefully dried, and kept in a well cloſed bottle.

Biſmuth is one of thoſe metallic ſubſtances which are partly ſeparated from acids by dilution with much water, and which cannot be kept diſſolved but by acids concentrated to a certain point, or when the acid is more than is ſufficient to ſaturate the metal. By the dilution of the acid, then, this operation is performed. The precipitate is very white; both becauſe a ſmall portion of acid remains united with it, which the water cannot take from it, and becauſe the nitrous acid has taken from the biſmuth moſt of its phlogiſton.

As biſmuth reſembles lead in many of its properties, ſome chemiſts obſerving that by mixing a ſolution of common ſalt with a ſolution of biſmuth in the nitrous acid, a white precipitate is formed, which alſo happens to ſolutions of ſilver and of lead, believed that in this precipitation the marine acid united with the biſmuth, and formed a *biſmuthum corneum*. But Mr. Pott, although he had been himſelf of this opinion, has ſhewn that the precipitation is cauſed merely by the water in which the common ſalt is diſſolved; ſince, when the ſolutions of biſmuth and of common ſalt contain the ſmalleſt poſſible quantity of water, no precipitation reſults from their mixture. Biſmuth, therefore, differs eſſentially from lead in this reſpect.

The chief uſe of the magiſtery of biſmuth is to enter into the compoſition of white paint uſed by ladies. It is preferred to all other whites from its ſuperior beauty, its luſtre, and an almoſt inſenſible tint of carnation, which renders it more ſimilar to the fineſt and whiteſt ſkin.

This advantage, which is very great, is counterbalanced by great faults. The ſkin is ſaid to be conſiderably ſpoiled by a continued uſe of it; it is alſo very apt to acquire a blackiſh color. Metallic ſubſtances and their calxes are known to be very apt to be impregnated with phlogiſton, when it touches them while it is in vapor, or in any other ſtate favorable to combination. By this means, whether they recover a part of the phlogiſton of which they have been deprived, or whether they receive it ſuperabundantly, they always acquire dark and blackiſh tints. But of all metallic calxes, that of biſmuth is one of the moſt ſuſceptible of this effect: its fine white becomes brown, and even leaden-colored, by a very ſlight expoſition to the phlogiſtic vapors; ſuch as the exhalations from houſes of office, from garlic, eggs, and particularly from liver of ſulphur. For this reaſon the white of biſmuth muſt be kept in well-cloſed bottles, otherwiſe it would be injured by circulating vapors which pervade paper coverings. From this property of biſmuth, it is rendered capable of affording a kind of ſympathetic ink. *See* Ink (Sympathetic).

Some artiſts prepare magiſtery of biſmuth by precipitating it from its ſolution in the nitrous acid, by a fixed alkali. But this method does not produce ſo good a white as the precipitation by water alone. The cauſe of this alſo is, that the calx of biſmuth very eaſily recovers its phlogiſton. Alkalis, however pure, always contain ſome ſuperabundant inflammable matter, and apply it to the metallic calxes which are precipitated, and particularly to the calx of biſmuth,

bismuth, which becomes more brown in proportion to the greater quantity which it takes of this inflammable matter. *See* BISMUTH.

CCCCXXIX. MAGISTERY *of* CORAL, CRABS-EYES, &c. Coral, crabs-eyes, pearl, shells, chalk, and other substances of that kind, are all absorbent and calcareous earths, easily soluble in nitrous acid, with which they form a nitre with an earthy basis. If the solutions of these matters be treated like the mother-water of nitre; that is, if they are precipitated by a fixed alkali, and afterwards well washed, all these earths will be obtained in a very divided state. The name of magistery is then given to them, together with the name of the substance which has been dissolved and precipitated. All these magisteries are nothing else but absorbent earths, which differ little from each other, or from magnesia. For the method of preparing these magisteries *see* MAGNESIA.

CCCCXXX. MAGNESIA ALBA. Magnesia is a white earth precipitated from the mother-waters of nitre and of common salt by a fixed alkali. It ought afterwards to be well edulcorated, to deprive it of all the saline particles it might retain.

To make magnesia, the mother-water of nitre, or of common salt, is placed in a large vessel, and diluted with a considerable quantity of common water; then a liquid fixed alkali is gradually poured upon it, and the mixture is to be agitated, which presently becomes turbid, and of a white milky color. In this manner alkali is to be added at different times, till no more precipitate is perceived; the liquor is to be further diluted with common water, if that be necessary for facilitating the earthy sediment: when this sediment is all formed, the liquor is to be decanted from it: it is then to be poured upon a filter of brown paper, supported by a cloth: pure water is poured upon it, till it is no longer capable of giving any taste to the water: the earth is then to be formed into troches or cakes, and left to dry. This is *magnesia*.

The mother-waters of nitre and of common salt are almost entirely composed, the former of nitre and sea-salt with earthy bases, and the latter of sea-salt with an earthy basis. *See* WATERS (MOTHER), NITRE, NITRE *with* EARTHY BASIS, WATER *of the* SEA *and* SALT FOUNTAINS, SALT (COMMON), SALT (SEA) *with* EARTHY BASIS. These salts are composed of nitrous and marine acids saturated with a calcareous earth, and are very deliquescent. They therefore do not crystallize; and great quantities of them remain dissolved in the last portions of liquor from which no more crystals can be obtained. Fixed alkalis being capable of decomposing all salts with earthy bases, and of separating their earth, do actually separate it in the present operation. Magnesia is then nothing else than a very much divided calcareous earth. It is employed in medicine as an absorbent earth, and is a very good one, from the fineness of its parts.

The mother-waters from which magnesia is to be precipitated, must necessarily be diluted in a very large quantity of water, because the absorbent earth dissolved by the nitrous and marine acids, is there in so large a quantity, that when an alkali is added to it without dilution, no precipitation seems at first to take place. The molecules of earth, not being capable of moving freely and of joining each other, do not form sensible molecules, and remain almost in the same state in which they were when they adhered to acids. But the sepa-

ration is nevertheless made, and so copiously, that the water of the mixture is found to be in too small a quantity, and that the whole becomes solid. This almost solid coagulation, which happens when two very fluid liquors are mixed, astonishes persons who do not understand the reason of it. It has accordingly been called the chemical miracle, *miraculum chemicum.* To prevent this coagulation, and to allow the earth to deposite itself, a sufficient quantity of water must be added.

After the precipitation is made, neutral salts with bases of fixed alkali remain in the liquor, which differ according to the kinds of acids which formed the salts with earthy bases, and according to the nature of the alkali employed for this decomposition. Thus, if the mineral fixed alkali had been employed, the neutral salt formed in the mother-water of sea-salt will be common salt, and the neutral salt formed by that alkali in the mother-water of nitre will be cubic nitre. If a fixed vegetable alkali has been employed, from the mother-water of common salt, the febrifugal salt of Sylvius may be obtained; and from the mother-water of nitre, not only that febrifugal salt, but also ordinary nitre may be obtained.

Hence, if magnesia be made in a very large quantity, the water, after the precipitate has been procured, ought not to be thrown away; as from it much good nitre and common salt may be obtained, according to the kind of mother-water employed. To obtain nitre, fixed vegetable alkali ought to be used; and to obtain common salt, the mineral alkali: the liquor is then to be evaporated, and crystals of these salts will be formed.

If the magnesia is not washed, it contains much of these salts. In that case, it would not be a simple absorbent, but would partake of the virtues of these salts. It would even be purgative in a certain dose: but as the quantity of salts which remains is always uncertain, when we intend that the magnesia shall contain any, it ought to be prepared in the ordinary method, and afterwards such doses of these salts as we shall judge proper may be added to it.

Some artists prepare magnesia without precipitation by an alkali. Their method is by evaporating the mother-water, and calcining the residuum in a crucible, to dissipate the acids: but this method is improper, because the magnesia by calcination acquires the property of quicklime.

If, instead of pouring fixed alkali into the mother-water, vitriolic acid be mixed with it, and if the mother-water has not been diluted with common water, a large quantity of a very white precipitate will be formed in it. Some authors have improperly called this precipitate magnesia; but it is of a very different nature from the earth properly so called. (*n*)

(*n*) This substance, distinguished by the name *magnesia alba*, from the dark-colored mineral called also *magnesia*, or *manganese*, has been accurately examined by Dr. Black. The experiments of that excellent chemist on this subject are related in the second vol. of the *Essays Philosophical and Literary, published at Edinburgh.* From these we learn the following results: 1. Magnesia is soluble with effervescence in vitriolic, nitrous, marine, and acetous acids. With vitriolic acid it formed crystals similar in all respects to those of the salt called *Epsom-salt.* With nitrous acid it formed crystals, which deliquiated in a moist air. With marine acid it did not form crystals; but the saline matter being evaporated to dryness, soon deliquiated by exposure to air. With distilled vinegar it formed no crystals by evaporation; but a saline mass, which, when

4 warm,

The ſediment formed by adding vitriolic acid, far from being a pure calcareous earth, conſiſts of that earth which this acid takes from the nitrous and marine acids, and forms with it a ſelenites. This ſelenites appears as a precipitate; becauſe, as it is very little ſoluble in water, it cannot be all ſuſpended or diſſolved in the liquor: but if a large quantity of water, eſpecially hot water, be added, this pretended magneſia either does not appear, or afterwards diſappears by being again diſſolved. This precipitate is not applied to any uſe. *See* SELENITES.

CCCCXXXI. MAGNESIA. (*o*)

warm, was viſcid, reſembling glue in color and conſiſtence, and when cold, was brittle. 2. By calcination, it loſt $\frac{7}{12}$ of its weight. When calcined, it did not effervesce with acids, whence the ſubſtance loſt by calcination was chiefly fixable air. This air, and almoſt all its weight loſt by calcination, was reſtored to it by ſolution in vitriolic acid, and precipitation from thence by a mild fixed alkali, the air of which it abſorbed. 3. By the laſt mentioned properties (2) it ſeemed analogous to calcareous earths, but differed from theſe earths, in the nature of the ſalts formed by it with acids (1), and alſo in other properties; but eſpecially in this, that even when calcined, it was not ſoluble in water. The Author of the Dictionary, therefore, improperly calls it a calcareous earth; this name being applicable to ſuch earths only as are convertible into quicklime. 4. It was precipitated from acids by volatile alkali. 5. When uncalcined, it precipitated calcareous earth from acids. When calcined, or otherwiſe deprived of air, it did not precipitate theſe earths: hence its attraction to acids is not greater than that of theſe earths; but the cauſe of the former precipitation was this, that the ſum of the forces which tended to join the calcareous earth with the fixable air of the magneſia, and the magneſia with the acid, was greater than the ſum of the forces which tended to join the calcareous earth with the acid, and the magneſia with the fixable air. 6. When uncalcined, or united with air, it precipitated lime from lime-water; which ſhews, that the calcareous earth had a ſtronger power to combine with fixable air than magneſia had, ſince the former earth took this air from the latter earth; by which means the former was rendered mild and unſoluble in water, and therefore was precipitated. This property ſuggeſted to Dr. Alſton a method of procuring ſweet water at ſea, by adding magneſia to water, the putrefaction of which had been prevented by the previous addition of quicklime. 7. By diſtillation of three ounces of magneſia, five drams of water, containing ſome ſmall portion of volatile alkali, were obtained.

(*o*) MAGNESIA, or MANGANESE, is commonly conſidered as an ore of iron; but the experiments of Mr. Pott and Mr. Cronſtedt ſhew, that this ſtone contains little or no iron, and therefore the latter author has made a diſtinct order of this earth, which he calls *terræ magneſiæ*. Its colors are dark-grey, black, red, or white. Its texture is ſtriated, or with concentric fibres, or indeterminate. It has the following properties: 1. It does not effervesce with acids; they, however, diſſolve ſome part of it, eſpecially when it is calcined: ſpirit of vitriol acquires from it a roſe color: aqua regia alſo acquires color, eſpecially from the black kind. From theſe ſolutions fixed alkalis precipitate a white earth. 2. A ſmall quantity of this earth, mixed with glaſs frit, gives red or purpliſh colors to the glaſs. By continuing the fuſion, theſe colors diſappear, and alſo other tinges which the glaſs may have accidentally received; hence it is uſed to produce colorleſs glaſs. Larger quantities of it are added when a deep purple glaſs is required. It is alſo uſed to give a glazing to pottery. 3. Fuſed with nitre or with fixed alkali, it gives to warm water various colors, green, purple, red, or blue, which change by agitating the water. 4. Cronſtedt affirms, that it deflagrates with nitre. Pott ſays, it does not. 5. Cronſtedt ſays, that he has ſometimes extracted a ſmall portion of tin from magneſia. 6. The ſame author affirms, that the colors given by magneſia to glaſs are eaſily deſtroyed by calxes of arſenic or of tin. Whence does its property

CCCCXXXII. M A G N E T. (*p*)

CCCCXXXIII, M A L T. The grain is ſo called which has been made to germinate, and afterwards dried, ſo as to become fit for the ſpirituous fermentation, or for making beer. *See* BEER.

CCCCXXXIV. M A N N A. *See* SUGAR.

CCCCXXXV. M A R B L E. (*q*)

CCCCXXXVI. M A R C A S I T E. This name has long been given indifferently to all ſorts of minerals, to ores, pyrites, and to ſemi-metals. Lately it ſeems to be confined to pyrites; and Mr. Wallerius propoſes to apply it only to ſuch pyrites as are regularly formed. This ſeems to be better than to leave it a vague and indeterminate ſignification, from the ambiguity and obſcurity which might thereby be introduced. *See* PYRITES.

CCCCXXXVII. M A R L E. (*r*)

CCCCXXXVIII. M A R S is the name of a planet which chemiſts have given to iron, and which is ſtill much uſed in medicine and chemiſtry. *See* IRON.

CCCCXXXIX. M A S T I C. (*s*)

CCCCXL. M A T R A S S. A matraſs is a bottle with a neck more or leſs long, uſed in chemiſtry for making digeſtions and macerations. Matraſſes are alſo uſed as receivers. Their form is different, ſome of them being ſpherical, which is the ordinary ſhape; others flattened at the bottom, called *matraſſes with a flat bottom*; and others having the figure of an egg, which laſt kind are called *philoſophical eggs*. Theſe matraſſes are choſen according to the operations intended. The moſt convenient of all, when we do not mean to operate on a large quantity of matter, are bottles of thin glaſs, known by the name of *medical phials*; becauſe theſe phials are very cheap, are made of good glaſs, and may be quickly heated, ſo that the liquor contained ſhall boil without danger of being broken. This advantage they owe to their thinneſs. Such phials are very uſeful in a laboratory; and therefore a number of them ought always to be kept there. *See* VESSELS.

of tinging glaſs proceed? Does it contain any of the known volatile metallic ſubſtances, or a new ſemi-metal?

(*p*) MAGNET. Magnets are iron-ores, from which a conſiderable [illegible]ortion of iron may be extracted. N[illegible] ſays, that they are almoſt totally ſoluble in ſpirit of nitre, and partially in the vitriolic and marine acids.

(*q*) [illegible]RBLES All thoſe calcareous ſtones [illegible]lled, which are hard, which have a [illegible] texture, are capable of receiving [illegible]ſh, and which are conſidered as [illegible] For their properties, *ſee* EARTHS [illegible]us).

[illegible]LE is an earth compoſed of different [illegible]tions of argillaceous and of calcareous earths. Its properties vary in degree according to the proportions of theſe earths. Marles effervеſce with acids, which property they receive from the calcareous earth. They are fuſible by fire, as all mixtures of theſe two earths are. By a leſs heat, if the calcareous earth predominates, they are calcinable into a kind of quicklime; and if the clay predominates, they may be changed by fire into hard maſſes capable of ſtriking ignited ſparks from ſteel.

(*s*) MASTIC is a reſin almoſt totally ſoluble in ſpirit of wine, but not at all in water. It becomes ſoft and tough, like wax, by being chewed. It is uſed as an ingredient in varniſhes.

CCCCXLI.

CCCCXLI. MATRIX. (t)

CCCCXLII. MATT. Ores not perfectly deprived of their ſulphur, when fuſed, are called *matt*. It is obtained in the firſt fuſion for the extraction of metal from ſome ores. *See* SMELTING *of* ORES.

CCCCXLIII. MENSTRUUM. Menſtruum is a word ſynonimous with ſolvent. *See* SOLUTION.

CCCCXLIV. MERCURY. Mercury is the name of a planet, which is alſo given to the metallic ſubſtance called *quick-ſilver*. But as mercury is the moſt general name, we ſhall here relate the principal properties of this metallic ſubſtance.

Mercury is a metallic ſubſtance of a ſhining white appearance, entirely ſimilar to that of ſilver. It is habitually fluid, and conſequently we cannot diſcover either its ductility or the tenacity of its integrant parts.

Its ſpecific gravity is very great: next to gold and platina, it is the heavieſt of all metallic ſubſtances, and even of all known natural bodies. It loſes about $\frac{1}{14}$ part of its weight in water, and a cubic foot of mercury weighs 947 pounds.

Neither air, water, nor the united action of theſe two elements, appear to make any ſenſible impreſſion upon mercury; nor is it more ſuſceptible of ruſt than the perfect metals. Its ſurface tarniſhes, nevertheleſs, to a certain degree, and more quickly than gold and ſilver, when it is expoſed to the air: but this is becauſe the duſt which floats in the air quickly fixes upon its ſurface. The watery vapors alſo which float in the air ſeem alſo to be attracted by the mercury.

Mercury may eaſily be cleanſed from thoſe extraneous matters which adhere only ſlightly to it, by making it paſs through a new, clean, and cloſe cloth, and afterwards by heating it. When mercury has been thus purified, and is free from all metallic allay, it is conſiderably fluid. A phoſphoric light is produced by ſhaking in the dark ſuch mercury contained in a barometer. Its integrant parts, like thoſe of melted metals, ſeem mutually to attract each other, and always acquire a convex or ſpherical form when they touch bodies with which they have no tendency to unite.

Mr. Lemeri the younger aſſerts, that mercury loſes no weight by being kept in boiling water; and therefore that water diſſolves none of it. Nevertheleſs, many good phyſicians are of opinion, that water which has been boiled upon mercury has the property of killing worms and other inſects; from which we may ſuſpect, that ſome mercurial parts are diſſolved by the water, although their quantity is too ſmall to be rendered ſenſible by a balance. Theſe experiments deſerve to be repeated with due attention.

Mercury, when expoſed to fire, preſents many remarkable phenomena. It ſeems to ſuffer no change from a heat that is not ſuperior to that of boiling water. With a greater heat it is entirely diſſipated in vapors, like other volatile bodies. It undergoes no alteration by having been thus reduced into vapor; for if the evaporation be made in cloſe veſſels, that is, if the mercury be

(t) MATRIX. The matrix of ores is the earthy and ſtony ſubſtances in which theſe metallic matters are generally inveloped. Theſe are very various, generally ſpar, quartz, fluors, or horn-blend. *See note to the article* ORES.

 diſtilled,

distilled, its vapors when condensed will form the same mercury as before the operation. Mercury remains unchangeable by repeated distillations. Boerhaave distilled 18 ounces of mercury 500 times, without perceiving any other change than that its fluidity and specific gravity were a little encreased, and that some grains of a fixed matter remained: which small changes were probably produced by a purification of the mercury, rather than by any real alteration of it. The vapors of mercury, like those of all other volatile bodies, if they cannot escape, or be condensed, cause violent explosions. Mr. Hellot, of the Academy of Sciences, says, that he was present at an experiment of this kind. A person pretending to fix mercury had enclosed some of it in an iron box closely welded. When the mercury was heated, it burst the iron box, and dissipated in invisible vapors.

By digestion in a strong heat, continued during several months, mercury undergoes a more sensible alteration; its surface being gradually changed into a reddish earthy powder, without any metallic lustre, which floats upon the surface of the fluid mercury, without incorporating with it. Thus any quantity of mercury may be entirely converted into a red powder. For this purpose only the proper time and vessels are required. As mercury, thus changed, resembles a metallic precipitate; and as, for this purpose, no addition is necessary; this preparation is called *mercurius precipitatus per se*, or mercury precipitated by itself.

The strongest heat which mercury can sustain is necessary for the preparation of this precipitate *per se*. For Boerhaave, who made long continued experiments upon this substance, with a patience unequalled even by the searchers for the art of making gold, kept mercury in digestion during 15 years, without observing any change, unless that upon its surface a little black powder had formed, which by trituration was easily reducible into fluid mercury. *See* PRECIPITATE PER SE.

Till lately it was believed that the fluidity of mercury was as essential to it in its natural state as its volatility: so that those even who had labored to render it fixed and solid, expected to attain their purpose only by producing a great change upon its nature. But at present we are assured that by a sufficient degree of cold it may be rendered solid and malleable like the other metals. This truth, which had been conjectured by theoretical chemists, has been lately demonstrated by the Members of the Academy at Petersbourgh. These philosophers availed themselves of the intense cold on Dec. 25, 1759, which they further encreased by the artificial methods known, and particularly by the mixture of spirit of nitre with snow, till Mr. de Lisle's thermometer was sunk to the 213th degree. They then perceived that the mercury in the thermometer no longer continued to mark the degrees of cold, and suspected that it had lost its fluidity. Having broken their thermometer, they found that their mercury was actually consolidated. They repeated this experiment upon other thermometers, and found that it succeeded so completely, that after having broken one of these instruments, they extracted the mercury in a solid state, which resembled a small globe of silver, with a flexible silver wire attached to it. They struck this mercurial globe several times with a hammer, and perceived that it was thereby flattened and extended like a ductile metal. Mr. Poissonnier, Physician of the Faculty of Paris, Physician to the King, and Member of the Academy at Petersbourgh,

Petersbourgh, who then happened to be in Russia, was present, and one of the operators at this important experiment, and was the person who first sent a particular account of it to the Academy of Sciences at Paris (*u*). By this capital experiment it is then well established and authenticated, that mercury is, like other metals, fluid or solid, according to the greater or less quantity of fire with which it is penetrated; that if we only see it in a fluid state, it is because it is so fusible that so small a degree of heat can keep it fluid, that even in the greatest natural colds, a sufficient quantity of heat always remains for that purpose.

This exceeding fusibility of mercury, and its great volatility, together with its great density and gravity, are properties which appear contrary and incompatible, to be found in the same body, and so eminently. In fact, the density, gravity, and solidity of metals, leave no doubt but that the earthy element enters in a great quantity into their composition; and besides, by the calcination of imperfect metals, this element is in some measure developed, and rendered so sensible by essential properties, that it undoubtedly makes part of metals. The extreme density and gravity of mercury seem to prove no less evidently that much of the earthy element enters into the composition of that substance. But on the other side, solidity and fixity seem to be essential properties of the earthy principle. How then shall we conceive, that a substance composed almost entirely of the most fixed and refractory principle, should be exceedingly volatile, and perhaps the most fusible of all bodies? This most undoubtedly proceeds from the presence of some other principle which is eminently volatile and fusible. But what is this principle? Is it phlogiston? or that principle which Becker has mentioned, but not ascertained, and which he calls *mercurial earth*? Is it the union of the inflammable principle and of this mercurial earth? These certainly are objects worthy the curiosity of those who have taste and talents for the sublimest researches in chemistry.

We proceed now to the other properties of mercury, which it discovers when combined with the principal chemical agents.

(*u*) The validity of this experiment, which seems to ascertain the fixation of mercury by cold, has been questioned by counsellor Lehman. According to this author, the mercury employed by professor Braun in the recited experiment had been distilled in the common method through water, and the water only in that experiment was frozen, but not the mercury. He also affirms, that having distilled mercury without water, and having carefully purified it from all watery particles, he could not congeal the mercury by artificial cold, although he at the same time did congeal common mercury. But I think that we must assent to the fixability of mercury by cold, as affirmed by the academicians of Petersburgh, unless we disbelieve what they affirm concerning the ductility of the mercury thus hardened, which could certainly not be given by the congelation of adhering water.

Nevertheless, mercury is said to attract powerfully moisture from the air. The explosions occasioned by exposing mercury suddenly to heat in close vessels are said by [illegible] to be produced by water adhering to the mercury. The water commonly obtained in distilling mercury which has been exposed to moist air, has induced a belief of the convertibility of mercury into water. Neuman says, that he has observed that the weight of mercury was greater in winter than in summer. Probably this difference proceeded from the mercury having acquired more moisture from the air in the former than in the latter season. *See* ENCYCLOP. tom. X. p. 273.

Vitriolic acid in its original state does not act,* or but very weakly, upon mercury. These two substances cannot be united together, unless the acid be very highly concentrated, and a very strong heat applied. These two conditions are united in distillation. Vitriolic acid, poured upon mercury and distilled, becomes more and more concentrated; and as it acquires a great heat when it is concentrated, it then acts upon the mercury, dissolves it, and reduces it to a saline, white mass.

In this operation we observe, that the portion of acid which passes in distillation is very much of the volatile sulphureous nature, which might induce us to suspect that the acid seizes part of the inflammable principle of the mercury. Nevertheless, when we afterwards separate the vitriolic acid from the mercury, we find that this metallic substance has received no alteration. This volatile sulphureous quality, therefore, seems more probably to be given to the vitriolic acid by some inflammable matter which the mercury had superabundantly, as most other metallic matters generally have. This deserves a more particular examination.

When the saline-mercurial combination which remains in the retort is mixed with pure water, it divides into two different matters, one of which is perfectly soluble in water, and the other precipitates in form of a white powder, if the water be cold; and of a yellow powder, if the water be hot, and in sufficient quantity. The portion which remains dissolved in the water is a combination of mercury with as much vitriolic acid as is necessary to give it a saline quality. It is a salt with a metallic basis, crystallizable by evaporation of the water. It ought to be called *vitriol of mercury*. The precipitated portion is almost entirely pure mercury, which retains too little acid to give it a saline quality, or solubility in water. It may be totally deprived of its acid, according to Mr. Beaumé, by a sufficient lavation with hot water. This precipitate becomes more and more yellow, when it is washed with hot water; it is a violent emetic, and is known by the name of *turbith mineral*. *See that article.*

If, instead of treating with water the combination of vitriolic acid and mercury which remains in the retort after distillation, it be cohobated several times with vitriolic acid, Lemery says, that the mercury becomes more and more impregnated with acid, and at last becomes a very corrosive liquor, which some chemists have improperly called *oil of mercury*.

If the combination of vitriolic acid with mercury be exposed to fire, the greatest part of this acid will be expelled; and this remarkable thing happens, that mercury treated thus with vitriolic acid sustains a greater heat, and consequently seems to be somewhat more fixed than when it is pure.

Nitrous acid dissolves mercury very readily; and this solution presents phenomena very similar to those of the solution of silver by the same acid. This acid ought to be very pure; the solution may be made without heat; it is corrosive, and blackens the skin, in the same manner as the solution of silver does. From this solution may be obtained by crystallization a nitrous mercurial salt, which may be called *mercurial nitre*. If this salt be exposed to the action of fire, much of the nitrous acid will be driven from it in the ordinary form of red vapors; and when the acid quits the mercury, the salt, which is at first very white, becomes yellow, then orange-colored, and lastly red. Mercury treated with

with this acid becomes also more fixed. Nevertheless, by a sufficient heat it may be sublimed.

The red powder which remains after the evaporation of the nitrous acid has the appearance of mercury precipitated by itself. It is called *red precipitate*, but improperly, for it is not a precipitate. *See* Precipitate. When spirit of wine has been poured upon it and burnt off, it is called *arcanum corallinum*. *See* Precipitate (Red).

Marine acid when liquid does not act sensibly upon mercury in its ordinary state, even when assisted with a boiling heat. But when this acid, very concentrated and reduced into vapors, meets mercury also in vapors, these two bodies easily unite together, and even intimately. Hence results a marine salt with basis of mercury, the crystals of which have the form of flattened needles. It is called *corrosive sublimate mercury*, or only *corrosive sublimate*, because it is always made by sublimation, and is at the same time a very violent corrosive.

Corrosive sublimate may be made in several methods. The most common is to take a solution of mercury evaporated to dryness, to mix it with a quantity of calcined martial vitriol and of decrepitated common salt equal to the quantity of mercury dissolved, and so proceed to sublimation by exposing the mixture to fire in a matrass set in a sand-bath. On one side the acid of vitriol disengages the acid of common salt which rises in vapors. On the other side, the mercury is reduced into vapors by the heat. These two bodies combine together in that state, and form a salt, which being itself volatile, attaches itself in the upper and colder part of the matrass, where it forms a very white and shining crystallized incrustation, which is the corrosive sublimate. The other methods of making this salt are founded on the same principles. They will be found under the article Corrosive Sublimate.

This salt is of a singular nature, and differs much from all the other combinations of mercury with other acids. Altho' it is extremely caustic, and is capable of receiving still a considerable quantity of mercury, as we shall afterwards observe when we speak of sweet mercury, (which qualities indicate an imperfect saturation of the acid) it nevertheless has none of the properties observable in those salts whose acids are imperfectly saturated. It crystallizes well, and very easily; so far is it from being deliquescent, as all these salts are, it is difficultly soluble in water, and requires a large quantity of boiling water to dissolve it entirely. It is consequently a salt which crystallizes by cold. Its crystals are of the same form as those obtained by sublimation, and cross each other irregularly. They resemble a heap of large sword-blades or poignards thrown carelessly together.

If corrosive sublimate be exposed to fire, it will again be sublimed in its original form, without being decomposed, or at least only insensibly. The mercury then, so far from receiving any fixity from the marine acid, as it does from the vitriolic and nitrous acids, seems on the contrary to be rendered more volatile. This phenomenon is analogous to those which are exhibited by other metallic substances with marine acid, the union of which renders all these substances more or less volatile. This acid ought to produce this effect more strongly upon mercury, as it is itself considerably volatile.

This property as well as the others which are peculiar to the combination of marine acid with mercury, are naturally deducible from the presence of

mercurial

mercurial earth existing abundantly in both these substances, if Becker's opinion upon this subject was sufficiently proved. *See* SUBLIMATE (CORROSIVE).

The affinity of marine acid with mercury is so great, that it overcharges itself in some measure with a considerable quantity of that metallic matter. If corrosive sublimate be triturated in a glass mortar with fluid mercury, it will receive the mercury and acquire a blackish color. By thus adding mercury till it no longer is extinguished (for this kind of combination is called *extinction*) which is known by the globules of mercury not disappearing, we shall find that corrosive sublimate is capable of absorbing or extinguishing about three quarters of its weight of fresh mercury. And if this new mixture be subjected to sublimation, the combination of mercury with corrosive sublimate is compleated, and a new sublimate is formed, in which the quantity of mercury is much greater than in corrosive sublimate. When this matter has been sublimed thrice, to render the combination more perfect and intimate, the sublimate is then called *mercurius sublimatus dulcis*, or more frequently *sweet mercury*, because the mercury which is then united to the marine acid forms a compound which is no longer caustic, and which is taken internally as a purgative. *See* MERCURY (SWEET). It is also called *aquila alba*, the white eagle, and this Latin name is still in use.

Corrosive sublimate is not only rendered less caustic by this addition of mercury, which changes it into sweet mercury, but also the properties of the marine acid, and even its saline qualities are, almost entirely abolished. Sweet mercury has not then, properly speaking, but the external appearance of a saline matter. It is almost entirely unsoluble in water, which is the most distinguishing mark of salts.

If sweet mercury be six times sublimed, it loses more and more of its purgative quality, and at last all of it. This change is produced either by a loss of part of the acid each time, or by the combination betwixt the acid and mercury being rendered more intimate. In this state it is called *mercurial panacea*, or merely *panacea*. The panacea taken internally in sufficient doses can then only produce salivation. *See* MERCURY (SWEET) *and* PANACEA.

The combinations of mercury with the vitriolic, nitrous, and marine acids, may be decomposed by all intermediate substances, which having in general a stronger affinity with acids than metallic substances, decompose all metallic solutions by acids. These intermediate substances are absorbent earths, and alkaline salts, both fixed and volatile.

Lime-water mixed with a solution of corrosive sublimate, precipitates the mercury in form of a red brick-colored powder. This mixture is employed in surgery under the name of *phagedenic water*. It is used for cleansing ulcers, particularly those which are venereal.

Fixed alkalis precipitate mercury from its solutions in a reddish powder; volatile alkali precipitates corrosive sublimate in a white powder, and the solution of mercury in nitrous acid in a grey slate-colored powder. In general, the colors of the mercurial precipitates are various, and these colors depend, like those of all other metallic precipitates, on the degree of division of parts, and on the quantity of saline matter and of phlogiston retained by these precipitates. *See* PRECIPITATE.

Fixed and volatile alkalis do not act, or but insensibly, on mercury, in its proper state; but they can dissolve it, as well as all other metallic matters, when they can be applied to these metallic matters very much divided, as, for example, previously dissolved by acids. Thus when a solution of mercury, with more acid than is necessary to dissolve the mercury, is poured into a very concentrated alkaline liquor, the precipitate formed upon first mixing the liquors will be again dissolved, and will disappear. The volatile alkali may by this management dissolve a very considerable quantity of mercury.

Lastly, vegetable acids which scarcely have any action upon ordinary mercury, are also capable of dissolving it when it is sufficiently divided. Thus if we pour a large quantity of distilled vinegar upon mercury precipitated by a fixed alkali from its solution in nitrous acid, this precipitate will be easily dissolved again by help of a little heat, and from this combination a mercurial salt of a singular nature will be formed.

The acid of vinegar, and probably all other vegetable acids, seem to be capable of contracting a very intimate union with mercury; for the *acetous mercurial salt* which we have just mentioned is not only crystallizable, but is even difficultly soluble in water. Hence, the phlegm of the vinegar not being in sufficient quantity to keep the acetous mercurial salt dissolved without heat, when it is made by the process described, this salt crystallizes in great quantity, when the liquor cools. Its crystals are small, shining, thin plates, floating in the liquor like pieces of silver leaf.

From all the solutions of mercury we have mentioned, we may see, that this metallic matter is capable of being combined with all acid or alkaline saline substances, but with more or less facility and intimacy. Of all the acids, the nitrous dissolves mercury most easily, as it does in general all metallic substances; but it has not the strongest affinity with mercury; on the contrary, it seems to be that which contracts with it the least intimate union, as we may see from the following experiments.

If into a solution of mercury made by spirit of nitre, vitriolic acid be poured, or the solution of any neutral salt containing this acid, the liquors will be rendered turbid; and when they are hot, a yellow precipitate will be formed, exactly similar to that which is obtained by pouring water upon the combination of vitriolic acid with mercury, that is to say, turbith mineral. This effect cannot happen but because the vitriolic acid is joined to the mercury, which it separates from the nitrous acid.

As this experiment is very manifest, as the turbith mineral is easily known, and as it may be formed from this solution of mercury in the nitrous acid, not only by the vitriolic acid when disengaged, but also by any salts which contain that acid; this solution of mercury, therefore, affords a convenient method of discovering the presence of that acid in many chemical experiments, and particularly in examining mineral waters. Accordingly, it is much used for that purpose; and is, with regard to the vitriolic acid, what the solution of silver in the nitrous acid is to the marine acid. *See* WATERS (MINERAL).

Marine acid, common salt, and in general all salts which contain this acid, mixed in a similar manner with a solution of mercury in nitrous acid, occasion a precipitate by the action of the marine acid upon the mercury, which it separates from the nitrous acid, and with which it unites, forming a combination,

which appears as a white precipitate, and is accordingly known by the name of the *white precipitate*. We muſt obſerve upon this ſubject, that that precipitate which is only a combination of marine acid with mercury, appears in theſe experiments as a precipitate, only becauſe it requires more water to keep it diſſolved than is to be found in theſe liquors; otherwiſe this mercurial ſalt would remain diſſolved, and would not become ſenſible. In this reſpect it differs eſſentially from turbith mineral, which is inſoluble in water.

The reaſon why this mercurial ſalt is much leſs ſoluble in water than the nitrous mercurial ſalt, is, that the marine acid is more intimately joined than the nitrous acid with the mercury; and alſo becauſe marine acid has ſo ſtrong an affinity with mercury, that it overcharges itſelf with that metallic matter, whenever it meets with a ſufficient quantity of it, as in the preſent experiment. For if we add to the white precipitate, to corroſive ſublimate, or to any other combination of marine acid with mercury, a much greater quantity of this acid diſengaged, theſe ſaline mercurial matters will charge themſelves with it ſuperabundantly, and will become ſo much more ſoluble in water, as they ſhall have received a larger quantity of this acid, according to the general rule. *See* SALTS.

Hence if white precipitate be made by pouring a conſiderable quantity of diſengaged marine acid into a ſolution of mercury by ſpirit of nitre, the precipitate ought to be re-diſſolved: and it accordingly is ſo, as Geoffroy, Junker, and Pott, have obſerved. As in this experiment, mercury is found diſſolved in a liquor containing the nitrous and marine acids, ſome chemiſts have imagined that mercury was ſoluble in aqua regia. Nevertheleſs nothing appears leſs certain than that concluſion. For it is very poſſible that mercury may be kept diſſolved by a ſuperabundant quantity of marine acid, with which only it is really united, and that the nitrous acid ſhould contribute nothing to this ſolution. Beſides, if the nitrous and marine acids could be both united to the ſame mercurial parts, why do the white precipitate and corroſive ſublimate, both made by help of a large quantity of nitrous acid, contain only the marine acid? The ſmalleſt veſtige of nitrous acid cannot be diſcovered in them.

Mr. Pott, in his Diſſertation on Common Salt, mentions another fact, which ſeems to prove not only, that mercury is ſoluble in aqua regia, but alſo that nitrous acid may ſeize upon that metallic matter excluſively of the marine acid. Mr. Pott's experiment conſiſts in pouring ſpirit of nitre upon corroſive ſublimate, by which he obſerved that ſpirit of ſalt was diſengaged in vapors.

A modern author draws from this experiment a conſequence againſt the greater affinity of the marine acid than of the nitrous with mercury, ſuppoſed by all chemiſts, and even againſt the doctrine concerning the tendencies of bodies to one another according to certain laws, called affinities. But, I believe, we may affirm that this experiment is only capable of impoſing upon us at firſt view, and not when we examine circumſtances attentively.

If indeed ſpirit of nitre be poured upon corroſive ſublimate, and particularly if the mixture be heated, we may obſerve the uſual phenomena of ſubſtances acting upon each other, that vapors are diſengaged, not of pure marine acid, but of aqua regia; and if the quantity of nitrous acid be ſufficiently large, that the corroſive ſublimate will be entirely diſſolved in it. But we muſt obſerve upon this ſubject, that as the quantity of mercury is very conſiderable in cor-

rosive sublimate, we cannot be surprized that nitrous acid, which has great dissolving power upon this metallic matter, and which probably finds it not sufficiently defended by marine acid, should exercise upon it part of its action; but on the other side, as nitrous acid fixes mercury a little, and as the mixture undergoes a certain degree of heat, it is scarcely possible but that a certain quantity of marine acid should disengage itself. But we may easily perceive that this effect is produced by the concurrence of these two circumstances, rather than by a superior affinity of the nitrous acid to the marine, with mercury. For when these two causes cease to act, that is, when the mixture becomes cool, and the action of the nitrous acid is over, the corrosive sublimate is seen to crystallize very quickly even in the nitrous acid, and in as large a quantity as before the experiment.

This is not the only fact which furnishes specious objections against even the most manifest affinities. But in good philosophy, when a single fact is found to contradict many others well established, it ought to be examined very attentively, and in all its circumstances, before the consequences it seems to contain ought to be inferred. We shall now return to our examination of white precipitate.

This combination of marine acid with mercury, being exposed to the action of fire in close vessels, is sublimed into a saline mass, which is considered by Lemery as a sweet mercury, by others as a corrosive sublimate, and, lastly, by some chemists as being in an intermediate state betwixt corrosive sublimate and sweet mercury. The last opinion seems to be the most probable; for the sublimate formed by white precipitate is probably not often charged with a sufficient quantity of marine acid to form corrosive sublimate, at least if by that expression we understand mercury sublimed, and united with the greatest possible quantity of marine acid; and on the other side, this sublimate from white precipitate probably contains too little mercury to constitute sweet mercury. But as the marine acid and mercury may be united in very different proportions, according to the state in which they are presented to each other, in this respect very considerable differences ought to be found in white precipitates, according to the methods of preparation. If, for example, mercury be precipitated by a large quantity of disengaged marine acid, this mercurial precipitate will most probably contain a much larger quantity of acid, than a precipitate made by adding common salt to the solution of mercury. If this be true, we need not be surprized that chemists should disagree in their opinions concerning the degree of corrosive quality to be attributed to this sublimate from white precipitate.

We have seen above, that the combinations of mercury with acids may be decomposed, as all metallic solutions may, by earths and by alkalis both fixed and volatile. They may be decomposed also, and particularly corrosive sublimate may, by several metallic substances, such as tin, regulus of antimony, and copper.

Corrosive sublimate, being mixed with tin and subjected to distillation, may be decomposed. The marine acid is applied to the tin, a part of which it carries with it in distillation, and with which it passes in form of an acid, smoking liquor. This acid is called the LIQUOR (SMOKING), *or* SMOKING SPIRIT *of* LIBAVIUS; which *see*.

Antimony or its regulus, being mixed and diſtilled with corroſive ſublimate, alſo decompoſe it; the regulus taking the marine acid from the mercury, and paſſing with that acid in form of a thick liquor, which congeals by cold, and is known by the name of BUTTER *of* ANTIMONY. *See that article.*

If very clean plates of copper be ſteeped in a ſolution of corroſive ſublimate, the acid of that ſalt will attack the copper, and the mercury will be depoſited upon the ſurface of the copper, with its metallic luſtre, which always happens when one metal is precipitated by another. *See* PRECIPITATION *and* PRECIPITATE.

As mercury revived is always fluid, and therefore capable of being allayed with any metallic matter which it can touch, it amalgamates in the preſent experiment with the ſurface of the copper, and forms there a beautiful, white, and ſhining ſilvering, capable of ſurprizing perſons ignorant of theſe effects, and of making them believe that copper is thus changed into ſilver. But to make this experiment ſucceed well, we muſt add ſome marine acid, or ſome ſal ammoniac to the ſolution of corroſive ſublimate. This experiment ſucceeds equally well with the ſolution of mercury in ſpirit of nitre, but always better when the acid is larger in quantity than is ſufficient to diſſolve the mercury. The ſurface of the copper immerſed in theſe liquors becomes inſtantly ſilvered, and then it muſt be immediately withdrawn, waſhed in clean water, and wiped by rubbing it with a dry cloth.

When corroſive ſublimate and the other combinations of mercury with acids are decompoſed by proper intermediate ſubſtances, the mercury is always by that operation *revived*, that is, reduced to a fluid ſtate, and is obtained in that ſtate when the operation is made by diſtillation, by giving a heat ſufficient to raiſe it. But when the intermediate ſubſtance is a compound body, ſuch as antimony, which contains a principle capable of uniting and ſubliming with mercury; then the mercury which is diſengaged from the corroſive ſublimate, inſtead of being revived, makes part of a new combination, and is ſublimed in form of cinnabar, if antimony was uſed, from the union it contracts with the ſulphur of the antimony. *See* BUTTER *of* ANTIMONY, *and* CINNABAR.

Sulphur acts ſtrongly on mercury. If theſe two ſubſtances be triturated together, the mercury will be eaſily divided; its molecules will be diſtributed betwixt thoſe of the ſulphur, and will adhere to it; the mixture will acquire a color more and more brown, or blackiſh, which is a certain ſign of the diviſion of the mercury; in a word, the mercury diſappears entirely, becauſe it is extinguiſhed and incorporated with the ſulphur. When the ſulphur has thus abſorbed all the mercury which it can receive in this method, the mixture is called *ethiops mineral*, from its black color.

The ſame combination may be made by fuſion, that is, by mixing the proper quantity of mercury with melted ſulphur. Theſe two ſubſtances unite together, as when triturated, and form a black compound, called *ethiops made by fire*. By this method the union of the ſulphur and of the mercury is made much more quickly, and ſomewhat more intimately. *See* ETHIOPS MINERAL.

When mercury and ſulphur have been united together only by fuſion or trituration, the union is not ſufficiently ſtrong, nor the proportions ſuitable for making the moſt perfect and moſt intimate combination, called *cinnabar*; for

for the preparation of which, sublimation is necessary. By sublimation of the ethiops, the mercury and sulphur are raised together, and are more intimately combined. But we must observe, that in this sublimation a part of the sulphur of the ethiops, which is superabundant to the combination of cinnabar, is separated; so that only one part of sulphur remains united in the cinnabar with six parts of mercury. This superabundant sulphur is not entirely separated by one sublimation. The sublimation must then be repeated several times, that the cinnabar may be entirely free from the superabundant sulphur. The sublimate, which is at first black like ethiops, becomes more and more red, as the mercury and sulphur approximate more and more to their proper proportions; and lastly, it remains in form of a very weighty, deep-red, striated mass, when the cinnabar is perfect. The red color of the cinnabar is so deep, because the matter is exceedingly dense; for when it is finely powdered, it acquires a fiery red color, and is then called *vermillion*, which is used in painting.

This combination of mercury with sulphur is found native, and is called *native cinnabar*, to distinguish it from that made by art. Native cinnabar is mercury mineralised, or the ore of mercury. *See* ORES.

The connexion of mercury and sulphur is so strong in cinnabar, that the principles of this compound are not disunited merely by the action of the fire, without burning the sulphur. Thus cinnabar exposed to fire in close vessels does only sublime, without any decomposition or alteration. To decompose, therefore, cinnabar, and to separate the mercury from it, some intermediate substance must be employed, which has greater affininity than mercury with sulphur. These intermediate substances are calcareous earths, fixed alkalis, iron, copper, lead, silver, and regulus of antimony. If, then, cinnabar be mixed with any of these substances, and be distilled, the mercury will disengage itself and pass into the receiver, where it will appear in its proper fluid form; and the sulphur will remain in the retort combined with the intermediate substance.

The mercury obtained in these operations is said to be *revived from cinnabar*. It is justly considered as the purest, and fittest for chemical and medicinal purposes, and even for the arts in some cases where very pure mercury is required.

The mercury obtained by the decomposition of cinnabar is not only very pure, but the whole quantity which was in the cinnabar is thus obtained, when none of it is lost in the operation; which proves that mercury suffers no alteration from the sulphur. *See* CINNABAR.

Mercury, which, from what we have said at the beginning of this article, is to be considered as a melted metal, also acts as such with regard to all earthy and metallic matters. Like other melted metals, it cannot contract any union with earthy substances, not even with metallic earths; but it may be very well allayed with almost all metallic matters in the following order: Gold, silver, lead, tin, copper, zinc, regulus of antimony. Iron is not numbered amongst the metals capable of uniting with mercury, because no method has yet been discovered by which they can be united together.

The allays of mercury with metals are called *amalgams*, and are employed for many important purposes. The amalgams of gold and silver are employed

 for

for gilding and ſilvering, and for the extraction of theſe two metals from their ores; that of ſilver is employed for preparing the *arbor Dianæ*; that of tin for ſilvering looking-glaſſes, for mercurial balls, and for the preparation of the ſmoking ſpirit of Libavius. *See all theſe words, and the articles* ALLAY *and* AMALGAM.

All fat and oily matters, vegetable or animal, act upon mercury. If mercury be triturated with any greaſe, it ſuffers an alteration ſimilar to that in the preparation of ethiops by trituration. The parts of the mercury are thereby very much divided, and made to unite with thoſe of the greaſe The mercury diſappears, is perfectly extinguiſhed, and acquires a black and leaden color. This combination of mercury and fat is called *mercurial ointment*, and is very uſeful in medicine; as we ſhall afterwards ſee.

The mercury in mercurial ointment muſt not be conſidered merely as diſtributed and intermixed with the parts of the fat: on the contrary, there is an adheſion and even intimate combination between the integrant parts of theſe two ſubſtances; for this fat very quickly becomes rancid, as all oily matters do when combined; and beſides, when mercurial ointment has been made a conſiderable time, all the mercury cannot be ſeparated from it even by fuſion. This fact has been verified by Mr. Beaumé.

Mercury, expoſed to the vapor of melted lead, or thrown into boiling linſeed oil, loſes its fluidity, and becomes ſo ſolid, that it may be formed into toys and ſmall utenſils. Although, properly ſpeaking, this is only an apparent fixation of mercury, ſince all its fluidity is reſtored to it by a little heat; this experiment proves, nevertheleſs, that ſome principle in theſe ſubſtances, probably their phlogiſton, is capable of acting ſenſibly upon mercury.

Perſons engaged in the diſcovery of the art of making gold, or of meliorating metals, conſidering that mercury has the metallic luſtre, and a gravity approaching to that of gold, have endeavored much to fix it; that is, to deprive it of its volatility and fluidity, intending always to give it the color of gold afterwards by a philoſophical tincture. The falſe fixations of mercury above-mentioned ſeem to indicate, that if any method by which mercury could be fixed were diſcovered, which is not very probable, this method muſt conſiſt in giving it ſome principle that it wants. Nevertheleſs, all the properties of mercury ſeem to ſhew, on the other ſide, that its fuſibility and volatility depend on ſome metallic principle united with it ſuperabundantly; and, conſequently, that its fixation ought rather to be effected by depriving it of ſome principle, than by any addition. However, we are certain that it muſt be effected by the one or the other, or by both theſe cauſes united. (*x*)

(*x*) The *purification of mercury* from extraneous ſubſtances is important for the purpoſes of medicine and of the arts, and eſpecially for ſome nice chemical operations. Mercury may be cleanſed from duſt, by ſtraining it through ſhamoy leather; from greaſe, by waſhing it with an alkaline lixivium; from any alkaline matter, by vinegar; from lead, or biſmuth, with which it is frequently adulterated, by diſtillation; from ſulphur, by mixing it with quicklime or with filings of iron, and then diſtilling the mixture. The beſt method of purifying mercury is by reducing it into ethiops mineral, with which twice the quantity of quicklime or of filings of iron is to be mixed; and by diſtilling it from this mixture. Its purity may be known, by obſerving that it does not ſoil clean white paper; that it has no pellicle on its ſurface; that when triturated with

Mercury is one of the metals which beſt deſerves to be well known, not only from its great importance to chemiſtry and to the arts, but alſo from the powerful remedies it furniſhes againſt diſeaſes incurable by other means, particularly thoſe called venereal diſeaſes. The medicinal uſe of mercury has been known only ſince the introduction of thoſe diſeaſes into Europe. The ancient phyſicians did not uſe it, but conſidered it as a poiſon. This opinion ſeems to have been founded upon ſome accidents from mercury ill prepared, or given improperly, or perhaps from the tremblings and diſeaſes to which artiſts who handle mercury much are ſubject. However that may be, the Arabian phyſicians were the firſt who ventured to uſe mercury medicinally, and they employed it ſucceſsfully againſt the itch, and other diſeaſes of the ſkin.

When the venereal diſeaſe firſt appeared in Europe, in the army of Charles VIII. at the ſiege of Naples, a phyſician, called Beranger de Carpi, conſidering that the new diſeaſe diſcovered itſelf by cutaneous puſtules, ſimilar to thoſe of malignant itches, and encouraged by the example of the Arabians, attempted the cure by mercury, and ſucceeded. Nearly about this time, chemiſts and alchemiſts directed much of their labors towards medicine, and diſcovered many chemical remedies, the beſt of which are preſerved, and employed at this time with ſucceſs. The famous Paracelſus chiefly diſtinguiſhed himſelf in this way,

with water, it does not ſoil the water; that when expoſed to fire in an iron ſpoon or laddle, it does not crackle; and, laſtly, that it is perfectly and entirely ſoluble in pure ſpirit of nitre, without any depoſition.

Mercury may be united with all metallic ſubſtances, excepting iron, arſenic, and the ſemi-metal called nickel. *See a note under the article* IRON. Dr. Lewis obſerves, that in ſome caſes mercury abſorbs gold and ſilver from their ſolutions in acid and in alkaline liquors. This it may do by precipitating theſe metals, from its greater affinity to thoſe menſtruums, and by uniting or amalgamating with the very minute particles thus precipitated.

The mercury of an amalgam expoſed to heat, raiſes along with it ſome of the amalgamated metal, even of gold, as happens in the gilding of metals by amalgamation. Mere diſtillation, therefore, may not be ſufficient to procure mercury perfectly pure from metals. By the above-mentioned method of mixing it with ſulphur ſo as to form an ethiops, and afterwards with quicklime, and by diſtilling the mercury from that mixture, it may be obtained well purified from metals, which will remain engaged in the ſulphur, or rather liver of ſulphur, formed by the ſulphur and quicklime. By no method can purer and brighter mercury be obtained than by diſtilling it from cinnabar, by intervention of filings of pure iron. In all diſtillations of mercury, the addition of filings of iron ſeems to render the mercury more fluid and bright; probably by giving phlogiſton.

The *volatility of mercury may be diminiſhed* by ſeveral methods; ſome of which we ſhall mention. 1. Mercury calcined by heat, called the precipitate *per ſe*, ſuſtains during ſome time a red heat, and by expoſure to the heat of a burning glaſs is vitrifiable. 2. Dr. Brandt relates a very curious experiment, from which mercury appears capable of being ſo detained and fixed by digeſtion with gold, that a conſiderable part of it cannot be ſeparated from this metal by the moſt intenſe heat. 3. Mercury may be rendered conſiderably leſs volatile by being combined with vitriolic acid, but eſpecially with the vitriol of ſilver, or the ſalt formed by ſilver and vitriolic acid. This ſalt may be united with a conſiderable portion of mercury, with which it forms a concrete ſubſtance fuſible by fire, but capable of ſuſtaining, according to Dr. Lewis, the greateſt heat that can be applied to glaſs veſſels, without diſſipation of the mercury. 4. Neuman ſays, that if mercury ſublimate be frequently ſublimed with ſal ammoniac, and each time the ſublimed matter mixed with the reſiduum, the whole becomes at laſt ſo fixed in the fire, that it cannot be any more ſublimed.

and treated venereal diseases with astonishing success, by internal remedies, in form of pills. Although he has not published his remedies, it is believed from their effect, that the basis of them was *turbith mineral.* Since that time mercury has been used in a great variety of forms.

Crude and fluid mercury taken internally produces no effect in the body; because the adhesion of its integrant parts to each other hinders their division, and distribution, or solution, without which it cannot have any effect. In its crude state, therefore, it does nothing but load the stomach and intestines. It falls downwards by its weight, and goes out of the body along with the feces in the same state in which it entered

Several physicians have believed that mercury, swallowed in its crude state, may be useful in the iliac passion, imagining, that by its weight it is capable of reducing the intestines to their proper situation. But the effects are not suitable to their expectations. We have even seen this disease rendered worse by mercury, from the shooting pains it occasioned in these parts, already pained and irritated by spasms. The use of crude mercury is now abolished in these diseases.

But when mercury is much divided, so that its molecules cannot again unite and form fluid mercury, in whatever manner this division may have been made, it then produces very striking effects, and such as may be expected from the most powerful remedies.

Mercury administered in this state accelerates the pulse, divides and carries off the thickened humors, augments in general all excretions and secretions, but some preferably to others, according to circumstances. If it be in a saline state, or capable of being easily put into one, and be thus introduced into the body by the stomach in sufficient quantity, it acts as an evacuant, purgative, or emetic. Mercurial frictions and fumigations chiefly encrease the secretion of saliva, and this in proportion to the quantity and number of doses. Mercury, in every form, if sufficiently divided, cures diseases; and every preparation has its peculiar advantages and disadvantages, which render it more or less adapted to particular circumstances. We shall here mention the effects of the ordinary preparations of mercury.

Mercury precipitated *per se*, being much divided, is capable of entering the blood-vessels; and when given in doses from two to six grains, properly repeated, produces salutary effects in venereal diseases. Notwithstanding that it contains no saline matter, it is frequently purgative and even emetic, and is then less disposed to salivate. But we must observe, that this preparation is a mercury exceedingly divided; that every body in this state, and mercury perhaps more than any other, is disposed to be attacked by every solvent; that it meets in the primæ viæ several substances, even of the saline kind, which are capable of dissolving it; and that then it must produce the effects of a saline mercurial combination, which effects are in general purgative or emetic. These properties of the precipitate *per se* shew, that it may be successfully employed in many cases. Nevertheless, this preparation is not much used, perhaps because it is very dear.

The combination of mercury with a sufficient quantity of vitriolic acid, to render it soluble in water, is very corrosive, and therefore not given internally.

Turbith mineral taken internally produces nearly the same effects, and in the same doses as the precipitate *per se*, and undoubtedly for the same reason; for

if it retains a little vitriolic acid, as most chemists have believed, this small quantity of acid seems to be sufficient to make it act as a saline mercurial combination: and if, on the contrary, when it is perfectly washed, no acid remains, it will be entirely similar to the precipitate *per se*, and, like this precipitate, will be disposed to receive a saline state, and to act in the same manner. Turbith mineral has been much commended, and is still used by some persons in venereal diseases.

All the precipitates of mercury, when separated from any acid by an alkali, and afterwards edulcorated, ought to produce internally the same effects as the precipitate *per se*, and as turbith mineral, supposing it to be freed from all acid by lotions. Thus the great number of such mercurial preparations nearly equivalent to each other, are but little used, which must be attributed to the want of attention to their nature and advantages.

The solution of mercury in the nitrous acid, and mercurial nitre, are justly ranked amongst corrosives.

Some persons, and Lemery amongst others, say, that they may be taken internally if they are diluted; an ounce of solution, for example, with 24 ounces of water or ptisan. This is called *mercurial water*.

Lemery says, that from half an ounce to an ounce of this mercurial water may be taken in a glass of ptisan, or broth, and that it vomits gently, and excites salivation. Mr. Baron, in his notes on Lemery, justly exclaims against the use of that dangerous remedy. Nevertheless physicians of great reputation have introduced, and even successfully, the use of corrosive sublimate for the cure of venereal diseases, although this preparation is no less corrosive than the solution of mercury in nitrous acid.

A pomatum is made of two ounces of mercury dissolved in a sufficient quantity of nitrous acid, and mixed perfectly well in a mortar with two pounds of hog's-lard. This pomatum admirably cures the itch. The solution of mercury acts powerfully upon the hogs lard with which it combines, and to which it gives greater solidity, while at the same time it is itself rendered thereby much milder. The pomatum is of a citron color, and is to be lightly rubbed upon the parts attacked by the itch, which by this treatment soon disappears. This pomatum for the itch comes from the Hotel-Dieu at Paris, where it is given to convalescents, by which they are quickly cured of the itch, which they all catch by remaining some time in the hospital. The receipt of this pomatum is also found in the last edition of the Dispensatory at Paris.

Red precipitate is not used internally, but is employed externally as a detergent and cicatrising escharotic, in the treatment of venereal ulcers.

All the combinations of mercury with marine acid are used. Of these the corrosive sublimate has been the least used, in France at least. The terrible accidents and deaths occasioned by small doses of this preparation have confined its use to external application, as an escharotic; and even then it is generally rendered milder, or rather decomposed by mixture with quicklime. But some years ago Van Swieten, a disciple of Boerhaave, and principal physician to the Empress-Queen, introduced the internal use of corrosive sublimate for the venereal disease. This great physician dissolved twelve grains of sublimate in two pounds of malt spirits, and gave this solution by spoonfuls, diluted copiously with emollient liquors.

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A great number of trials made by Van Swieten and many others of the profession have proved, beyond any possibility of doubt, that corrosive sublimate, administered in this manner, is a powerful anti-venereal, capable of curing inveterate poxes, which have resisted the other ordinary preparations of mercury. We know besides, that the internal use of corrosive sublimate has been long established amongst the Tartars and amongst the Russians, whose unrestrained manner of living with all sorts of women exposes them to a continual accumulation of venereal diseases.

But notwithstanding these powerful motives to confide in this remedy, many excellent physicians are still deterred from the use of it. They observe, that the use of corrosive sublimate seems only to agree with cold climates, and they believe that it always has disagreeable consequences in such as are hot or temperate. They think that a number of compleat cures, without any seeming inconveniencies, do not justify the use of a substance which is so corrosive, that very bad consequences may be apprehended from it, when it has been once introduced into the body.

Opinions therefore are still divided upon the internal use of corrosive sublimate. Time and experience must decide concerning them. But this is certain, that a remedy of this kind cannot be administered with too much caution, prudence, and discernment; that every one ought not to pretend to meddle with it; and that this, and most other very active substances are kinds of poisons, and only become powerful remedies in the hands of able physicians.

If it were once established, that corrosive sublimate given internally cures venereal diseases radically, and without troublesome consequences, we should think it certain, that the saline combinations of mercury with the other acids may be employed as safely for the same purposes; that is, the vitriolic and nitrous mercurial salts; for these salts are not more, perhaps less, caustic than corrosive sublimate: and besides, the vitriolic and nitrous acids being more disposed to unite with oily matters than the marine acid, they are therefore more susceptible of being rendered milder within the body than the corrosive sublimate, which ought therefore to be considered as the most dangerous of all that are used in medicine.

Sweet mercury, not being corrosive, may certainly be used internally, and has been so a long time. But notwithstanding the great quantity of mercury with which the marine acid in this compound is charged, it still retains sensibly a saline quality, and is purgative, when taken from four grains to 15 or 18. It is used in the treatment of venereal diseases, particularly when it is intended to purge. But it is not usual to attempt the cure of a true pox by this remedy only. The *mercurial panacea*, which is only apparently saline, acts, when taken internally, simply as mercury deprived of its fluidity, but too little divided to acquire a saline quality in the alimentary canal: accordingly it does not generally purge, but rather salivate, when given in a large enough quantity. The dose of it is from ten grains to twenty-four or thirty. It is to be repeated as occasion requires, and at proper intervals. Several persons of the profession cure the pox by this remedy only.

White precipitate, however it be made, is much more saline than sweet mercury. Accordingly it excites vomiting, and must be given more cautiously and in less quantity; but it is little used. Nevertheless, if the propriety of using corrosive sublimate were established, this precipitate may also be advantageously

advantageoufly employed with proper management. It would probably produce the fame effects in a larger dofe.

No fenfible effect is produced by the combinations of mercury with fulphur, whether *ethiops* or *cinnabar*, taken internally, and in large dofes. Some phyficians therefore reject thefe mercurial preparations as ufelefs and inactive. This is certain, that mercury united with fulphur has no faline quality, and is very little acted upon by menftruums, becaufe it is defended by the fulphur, nearly as the regulus of antimony is in antimony. Cinnabar is ufed neverthelefs in venereal difeafes, and fuccefsfully on certain occafions, and then it is decompofed by burning. The body of the patient is expofed to the vapors of mercury, which are difengaged by this burning. Thefe mercurial vapors infinuate themfelves through the pores of the fkin, excite falivation, and cure the venereal difeafe. This is called *the method by fumigation.*

We know yet very little the effects which are produced by combinations of mercury with vegetable acids, if it be true that Keyfer's pills have for their bafis the acetous mercurial falt, as is very probable. We may neverthelefs fuppofe that mercury adminiftered in this form might produce good effects.

Laftly, of all the preparations of mercury, the moft generally employed is certainly that called *mercurial ointment.* It is, as we mentioned above, mercury extinguifhed by trituration with fat. The only method of ufing this ointment is by rubbing it on the body of the patient, and repeating this friction at proper intervals and in proper dofes, till a fufficient quantity of mercury has been introduced to effect a cure. This is called *the method of friction.*

This method is more prevalent than the others. It is recommended by the beft phyficians, and particularly by the learned Aftruc. The chief motives for this preference are, that mercury introduced by this method has no corrofive quality, and that as much of it as is neceffary for the cure may be thus introduced without inconvenience.

Mercury adminiftered by friction or by fumigation produces no purgative or emetic effect, becaufe it does not enter into the body by digeftion, but is immediately introduced into the lymphatic and blood veffels. There it circulates, and penetrates into their moft remote receffes. When fufficient dofes of it are given, it produces almoft always a falivation more or lefs ftrong, makes the fymptoms difappear, and fubdues at length the venereal poifon.

This is all that we know concerning the effects produced by mercury. The nature of this poifon, and the precife manner of the action of the mercury, are ftill unknown. Many phyficians believe, that, as mercury is capable of a divifion into very minute but weighty globules, thefe globules act mechanically by their number and by their weight upon the lymph, which they fuppofed to be thickened and coagulated by the venereal poifon, and which by this action of the mercury was attenuated, divided, and reftored to its ordinary ftate. But this opinion, although one of the moft fpecious that has appeared upon the fubject, is neverthelefs far from the truth; for if this opinion were juft, mercury could only, while it was fluid and in its proper ftate, cure the venereal difeafe. But experience has proved inconteftably, that mercury in a faline ftate, fuch as it is in corrofive fublimate, and confequently deprived of all the properties of ordinary mercury, cures the pox effectually, and particularly in a dofe infinitely lefs than when it is adminiftered by friction or fumigation.

Hitherto it ſeems to have been believed, that mercury in the mercurial ointment is only divided, diſperſed, and interpoſed betwixt the parts of the fat, without being truly diſſolved and combined; and this undoubtedly has given cauſe to the above-mentioned opnion. We are nevertheleſs certain, that much of the mercury contained in the ointment is really combined either with the acid, or with the whole ſubſtance of the fat. This being eſtabliſhed, may we not conclude, that mercury cannot cure the venereal diſeaſe but when it is really diſſolved, and deprived of its properties of fluid mercury; that only the portion of mercury in the ointment, which is thus combined, affects the cure, and that the other portion of the mercury which remains in its natural ſtate in the ointment (for much of the mercury is in this ſtate) paſſes into the body without producing any effect; for which reaſon the mercurial ſalts cure in much leſs doſes than the mercurial ointment; that, laſtly, if the portion of mercury introduced into the body in its proper ſtate by friction or fumigation contributes to the cure, the reaſon of it is, that the moſt divided part of this mercury unites within the body with ſome greaſy or other ſubſtance with which it is capable of combining?

If this be true, ought we not to ſearch for ſome new combination of mercury, which ſhall be at the ſame time very ſoluble and free from cauſticity? Such a remedy would certainly be very precious. For although the mercury of the mercurial ointment is not cauſtic, and although the method by friction is undoubtedly the moſt advantageous and certain, it is not however free from inconveniencies. It frequently expoſes to dangerous ſalivations, accompanied with very troubleſome accidents; and if to avoid them, the quantity of ointment be diminiſhed, and the intervals of the ſeveral frictions lengthened, by which indeed theſe accidents are avoided, the cure then is not only of a tedious length, but is alſo ſometimes imperfect, or leſs certain.

But have we reaſon to flatter ourſelves with the hopes of finding ſuch a preparation of mercury? If we conſider that mercury has been tried in a great variety of methods, and by very able chemiſts, and that, notwithſtanding, no preparation has yet been found free from inconveniencies, we ſhall be apt to deſpair of ſucceſs in this inquiry. But on the other ſide, if we reflect on the nature and properties of mercury; if we conſider that this ſingular ſubſtance, as we have ſeen in the preſent article, is perhaps one of thoſe which may be combined in the greateſt variety of manners; that it is acted upon by almoſt every ſolvent; we may ſtill have hopes of finding a mercurial preparation, not only much ſuperior to thoſe hitherto known, but which perhaps ſhall be attended with no inconvenience.

The uſe of mercury is not confined to the venereal diſeaſe. We have already ſeen, that its antivenereal quality was diſcovered from its property of curing the itch, even the moſt malignant; and, in fact, it does cure much more readily and efficaciouſly than any other remedy, not only the ſeveral kinds of the itch, but alſo many other cutaneous diſeaſes more or leſs ſimilar to the itch, and which are very various.

Another medicinal quality of mercury is, that of deſtroying the worms and inſects of all kinds which are apt to infeſt the human body, either internally or externally. In the cure of theſe two latter kinds of diſeaſes, the ſame preparations of mercury, but ſmaller quantities, are employed as for the venereal diſeaſe.

Laſtly,

Laſtly, ſome obſervations made lately by able phyſicians ſeem to give hopes, that by mercury another ſcourge more terrible, but fortunately leſs frequent, than thoſe diſeaſes above-mentioned, namely, the madneſs occaſioned by the bite of a mad dog, may be cured. But this effect of mercury is not ſufficiently eſtabliſhed, and requires to be confirmed by many new obſervations, which would require a conſiderable time, ſince happily the occaſions of trying them are not very frequent.

Phyſicians, ſtruck with the ſurprizing ſucceſs of mercury in certain very obſtinate and otherwiſe incurable diſeaſes, were induced to try it in moſt of the other diſeaſes which were incurable by the ordinary remedies; and particularly in thoſe which were attributed, as well as the venereal diſeaſe, to a thickneſs or coagulation of lymph, ſuch as the ſcrophula, cancers, ſchirrhus, and others of this kind. But mercury was not found to have any good effect in theſe diſeaſes; and ſome diſeaſes, ſuch as the ſcurvy, the ſymptoms of which are ſo like thoſe of the pox that they cannot eaſily be diſtinguiſhed, were not only not diminiſhed, but aggravated by mercury.

We may ſtill however hope, that ſo powerful a remedy may be employed ſucceſsfully in other diſeaſes Perhaps for this purpoſe only ſome new method of preparing it is wanting. But even at preſent, it is one of our moſt valuable remedies.

CCCCXLV. MERCURY (ANIMATED). This is mercury purified by alchemical proceſſes, for the preparation of the philoſopher's ſtone.

CCCCXLVI. MERCURY (SWEET). Sweet mercury, called alſo *aquila alba*, is corroſive ſublimate combined by further operations with all the mercury which it can receive, and afterwards ſublimed thrice.

To make ſweet mercury, corroſive ſublimate is to be triturated carefully in a glaſs mortar with fluid mercury, which is to be added gradually as it diſappears. This is to be continued till the corroſive ſublimate is ſaturated and will receive no more mercury, which is known by the globules not diſappearing by trituration. Lemery ſays, that corroſive ſublimate can only receive about three quarters of its weight of freſh mercury; nevertheleſs a larger quantity, a half, may without inconvenience be added, becauſe thereby the corroſive ſublimate will be more perfectly edulcorated, and the ſuperabundant mercury will be eaſily diſengaged; as we ſhall ſoon ſee.

The corroſive ſublimate receives from the mercury with which it is triturated a blackiſh-grey color, which color mercury always acquires when it is much divided, and ſtill retains its metallic ſtate. This grey matter is to be put into one or more matraſſes with ſhort necks, or rather into the veſſels called medical phials, ſo that two-thirds of the containing veſſel ſhall be empty for the ſake of the ſublimation.

Theſe matraſſes are to be placed in a ſand-bath, and ſunk in ſand to the height of the contained matter. The fire is then to be gradually augmented till we ſee that the ſublimation begins. It is then to be kept in this ſtate till it be all ſublimed, and attached to the top of the veſſel, excepting a ſmall portion of fixed matter which remains at the bottom. When the matraſſes are cold, they are to be carefully broken. The white compact ſublimate is to be ſeparated from ſome leſs white and denſe adhering to the neck of the veſſel, to be again powdered, and ſublimed a ſecond and a third time in the ſame manner, always taking care to ſeparate each time the compact white maſs from that part which

has leſs of theſe qualities. The ſweet mercury is then in its moſt perfect ſtate, a white, heavy, ſemitranſparent maſs, ſmooth as glaſs in its convex part, where it adhered to the veſſel.

In theſe operations no mortars muſt be employed, upon which the acid or the mercury of the corroſive ſublimate can act: therefore neither marble nor metal mortars are proper, but thoſe made of glaſs.

Although the crude mercury which is triturated with the corroſive ſublimate is joined to it ſuperabundantly, and contracts with it a certain degree of union, this union is not nearly ſo intimate as it may be, and as it is after the perfect dulcification of the corroſive ſublimate; for if we take internally corroſive ſublimate impregnated by trituration alone, with all the crude mercury which it can perfectly extinguiſh, it would produce nevertheleſs very violent corroſive effects. By ſublimation then the new mercury is completely combined with the acid of corroſive ſublimate, which is thus rendered milder. The external mark of this intimate combination is the change of color from an opake grey, which the matter had before ſublimation, to a tranſparent white, which it afterwards acquires. This opake grey color proceeds, as we ſaid, from the mercury preſerving its metallic ſtate, which it does becauſe it is not intimately enough combined with the acid; and the white, tranſparent, ſaline appearance is a certain ſign of this intimate combination.

One or two ſublimations are not ſufficient to change entirely the corroſive ſublimate into ſweet mercury; experience ſhews that three ſublimations are neceſſary. The mercurial ſublimate may then be taken internally without danger. It is no longer corroſive, nor retains any more of its ſaline property than is ſufficient to render it purgative in a doſe from four or five to twenty-four or thirty grains: and if ſweet mercury be ſublimed eight or nine times, or perhaps leſs, it loſes its purgative quality, and is then called Mercurial Panacea. *See* Panacea.

The matter which adheres to the neck of the retort, particularly in the firſt ſublimations, is an imperfect combination of crude mercury with corroſive ſublimate, and muſt therefore be ſeparated from the reſt of the maſs. When the quantity of crude mercury triturated with corroſive ſublimate is more than can be united with it into ſweet mercury, the ſuperabundant mercury remains in its metallic ſtate, and gives a grey or blackiſh color to the ſweet mercury. This ſuperabundant mercury may be diſengaged by ſubliming in a retort, as Stahl propoſes, and as Mr. Baron remarks in his Notes on Lemery.

The fixed matter which remains at the bottom of the matraſs is quite extraneous to the mercurial ſublimate. It is a portion of earthy ſubſtances proceeding from the ſalts employed in the preparation of corroſive ſublimate, and which this ſublimate had carried along with it in ſublimation. For, in general, volatile bodies are capable of carrying along with them a part of the fixed bodies with which they happen to be mixed, particularly when they are expoſed to a ſtronger heat than is neceſſary for their ſublimation. For this purpoſe no union betwixt the fixed and the volatile bodies is neceſſary. This is done by a purely mechanical impulſion of the volatile parts againſt the parts of the fixed body. Hence the heavieſt volatile bodies muſt produce this effect more ſenſibly than thoſe which are lighter. Accordingly, the ſublimates of mercury, which are certainly the heavieſt of all volatile bodies, produce this effect ſurprizingly. For in the operation for ſweet mercury, ſometimes fragments of

of the matrasses in which the sublimation had been made, and which adhere to the matter which is again to be sublimed, are raised along with the mercurial sublimate. Mr. Beaumé has frequently found large fragments of glass in the middle of masses of the sublimates, which had been made in great works, where the same care and attention are not given as in the small operations of chemical laboratories.

Lemery remarks, that sweet mercury acquires a yellowish color when it is triturated. This color proceeds from the quantity of mercury being considerable with respect to the acid; for that is the ordinary color of mercury when it is much divided, and has not its metallic lustre, as we see from the example of the precipitate *per se*, of turbith mineral, and other preparations of mercury which are in this state. *See* MERCURY, *and* SUBLIMATE (CORROSIVE).

CCCCXLVII. MERCURY *of* PHILOSOPHERS. Alchemists have given the name of mercury to many other things besides the metallic substance generally so called. This latter they call ordinary mercury, and value it little. We cannot precisely say what they meant by their mercury, from the obscurity of their writings, and also from their different descriptions of the matter. No term is more frequently used by them than this. In every page of their writings we find the words mercury, mercurification, &c. Probably they had not all the same idea annexed to the term *philosophical mercury*. The most probable opinion upon this subject is, that this mercury is the metallic principle which Beccher has called *mercurial earth*. *See* EARTH (MERCURIAL), *and the following article*.

CCCCXLVIII. MERCURIFICATION. Mercurification is an alchemical operation, by which metals are said to be reduced into a fluid, heavy, opake, and shining liquor, like ordinary mercury; or by which the mercurial principle may be extracted from metals, and obtained in the form of quicksilver. But, these mercurified metals, or their mercurial principle rendered sensible, are a kind of philosophical mercury, which, although they resemble ordinary mercury, are nevertheless said, by persons exercised in such studies, to differ from it considerably, by having a greater specific gravity, by more effectually penetrating and dissolving metals, by a stronger adhesion to these, and by a less volatility.

We may find in the books of many authors, who, though not alchemists, give more or less attention to these subjects, a great number of processes for mercurification, or for obtaining the mercury of metals; most of which are very long, laborious, confused, and consequently subject to fail. The detail of these processes would be too long. An account of the principal of these operations may be seen in *Junker's Conspectus Chemiæ*. We shall only mention some of the easiest mercurifications, extracted from the most modern authors, as *Wallerius* and *Teichmeyert*.

If cinnabar of antimony made with corrosive sublimate be distilled, we shall obtain, by reviving the mercury, a larger quantity of mercury than was originally in the corrosive sublimate.

If a corrosive sublimate be prepared with spirit of salt and fluid mercury, and if calx or filings of silver be several times sublimed together with this corrosive sublimate, a part of the silver will be changed into mercury.

Very fine filings of iron, exposed during a year to the air, and afterwards well triturated in a mortar, and cleansed from dust and extraneous matter, then

expofed during another year to the air, and, laftly, diftilled in a retort, furnifhes a hard matter which attaches itfelf to the neck of the retort, and with this matter a little mercury. *Teichmeyert.*

If calx of copper be mixed with fal ammoniac, and this mixture expofed during a certain time to air, and diftilled with foap, mercury will be obtained.

If luna cornea or plumbum corneum be mixed with an equal weight of very concentrated fpirit of falt, digefted together during three or four weeks, then an equal quantity of black flux and Venice foap added to it, and the whole matter diftilled in a glafs retort, fome mercury will pafs into the receiver.

Thefe experiments are important and eafily made, but have not been repeated by modern chemifts; for which we fee no other reafon than the fmall hopes of their fucceeding. If they fhould fucceed, they would afcertain the exiftence of a mercurial principle in metals, and would fo much more confirm the theory of Beccher, as all the experiments above-mentioned are made with the marine acid, which that chemift fuppofes to contain the mercurial earth. The conclufion deducible from thefe experiments would be, that, by introducing a fuperabundant quantity of mercurial earth into metals, a true mercury might be obtained from them. *See* METALS.

Many other proceffes for mercurification may be feen in authors who have treated of this matter, particularly in Junker's book above quoted, in which marine acid is not employed, but other faline matters, or fublimation through the burning fuel, with concourfe of free air, in Geber's manner. In this latter cafe, we muft look for the mercurial fubftance in the metallic fumes and flowers; and if any fuch fubftance be obtained, it muft evidently proceed from the decompofition of the metallic matter employed.

Mr. Groffe fays, in the Memoirs of the Academy, that he obtained mercury from lead by an eafier and fimpler procefs than thofe above-mentioned. This confifts in faturating perfectly fome good nitrous acid with lead, which may be done effectually by employing more lead than the acid can diffolve; and from this folution, according to Mr. Groffe, a grey powder is precipitated, in which mercury is difcovered. This experiment being fhort, Meffrs. Macquer and Beaumé repeated it with due attention in their Courfe of Chemiftry; but they did not find the grey mercurial powder mentioned by Mr. Groffe. As the exactnefs and veracity of that able chemift are well known, we muft believe that the lead which he employed contained fome extraneous mercury, which might eafily happen in a laboratory. The fame thing has poffibly happened in other experiments of mercurification; and this proves how circumfpect we ought to be in drawing conclufions.

CCCXLIX. METALS *and* METALLISATION. Under the general name *metal*, we comprehend here not only the metals properly fo called, but alfo the femimetals, or all matters which have the effential metallic properties, which we fhall here recount. Thus the word *metal* and *metallic fubftance* will be fynonimous in this article.

Metallic fubftances form a clafs of bodies not very numerous, of very great importance in chemiftry, medicine, arts, and the ordinary affairs of life. Thefe fubftances have very peculiar properties, by which they differ from all other bodies.

The

The natural bodies from which metals differ the leaſt are earthy and pyritous matters, on account of their ſolidity and denſity. Metals and ſtones are, nevertheleſs, very different, the heavieſt ſtones which are unmetallic being much lighter than the lighteſt metals. A cubic foot of marble weighs 252 pounds; and an equal bulk of tin, the lighteſt of metals, weighs 516 pounds. The difference is much greater when the weight of ſuch a ſtone is compared with that of gold, a cubic foot of which is 1326 pounds.

Opacity is another quality which metals poſſeſs eminently; the opacity of metals being much greater than the opacity of any unmetallic ſubſtance.

This great opacity of metals is a conſequence of their denſity, and theſe two properties produce a third, peculiar alſo to metals, namely, a capacity of reflecting infinitely more light than any other body: hence metals whoſe ſurfaces are poliſhed, form mirrors repreſenting the images of bodies, more clearly than any other matter. Thus looking-glaſſes produce their reflexion merely by the ſilvering, which is a covering of metal upon their ſurfaces. To this reflective property metals owe their peculiar luſtre, called the *metallic luſtre*.

Although the ſeveral metallic ſubſtances differ conſiderably in hardneſs and fuſibility, we may ſay in general, that they are leſs hard and leſs fuſible than pure earths.

Metals cannot unite with any earthy ſubſtance, not even with their own earths, when theſe are deprived of their metallic ſtate: hence when they are melted, they naturally run into globes, as much as the abſolute gravity of their maſs, and their preſſure upon the containing veſſels, will allow. Accordingly, the ſurface of a metal in fuſion is always convex. A metal in that ſtate always endeavors to acquire a ſpherical form, which it does more perfectly as the maſs is leſs. This effect is very ſenſible in quickſilver, which is nothing but a metal habitually fluid or fuſed. A maſs of ſeveral pounds of mercury, contained in a ſhallow, wide-mouthed veſſel, is ſo ſpread out, that its upper ſurface is almoſt flat, and the convexity is not very ſenſible but at its circumference: on the contrary, if we put very ſmall maſſes of mercury into the ſame veſſel, as, for inſtance, maſſes weighing a grain each, they become ſo round as to ſeem perfect globes. This effect is partly occaſioned by the inaptitude of metals to unite with the veſſels containing them when in fuſion; by which quality the whole affinity which ſubſiſts betwixt the integrant parts of theſe metals is capable of acting; and partly alſo by this affinity, which diſpoſes the integrant parts to come as near to each other as they can, and conſequently to form a ſphere.

This property is not peculiar to melted metals, but to all fluids, when contiguous to bodies ſolid or fluid, with which they have no tendency to unite. Thus, for inſtance, maſſes of water upon oily bodies, or oily maſſes upon bodies moiſtened with water, aſſume always a form ſo much nearer to the ſpherical as they are ſmaller. Even a large drop of oil poured upon a watery liquor, ſo that it ſhall be ſurrounded with this liquor, becomes a perfect ſphere.

All metals are in general ſoluble by all acids; but often theſe ſolutions require particular treatment and circumſtances, which are mentioned under the articles of the ſeveral metals. With acids, they form neutral ſalts with metallic baſes. Theſe ſalts have all more or leſs cauſticity, which proceeds from the little intimacy of union betwixt the acid and metal, and from the great weight of the latter ſubſtance. The affinity of metals is leſs than of abſorbent earths

and

and alkaline falts to acids; and therefore any metal may be feparated from any acid by thefe earthy and faline alkalis.

Alkaline falts are capable of acting upon all metallic fubftances, and of keeping them diffolved by proper management.

Metals may in general be united with fulphur and liver of fulphur. With fulphur they form compounds refembling the peculiar fubftance of ores, which are generally nothing elfe than natural combinations of fulphur and metal. Metals have lefs affinity with fulphur than with acids; hence fulphur may be feparated from them by acids. Some exceptions from thefe general rules, concerning the affinity of metals to fulphur and liver of fulphur, and concerning their feparation from fulphur by acids, may be feen under the articles of the feveral metals. But thefe exceptions do probably take place, only becaufe we have not yet found the method of furmounting fome obftacles which occur in the ordinary methods of treating certain metals.

All metals may in general be united with each other, with which they form different allays which have peculiar properties; but this rule alfo is not without fome exceptions. *See* ALLAY *and* AMALGAM.

Metals have ftrong affinity with the inflammable principle, and are capable of receiving it fuperabundantly.

Laftly, oily fubftances feem to be capable of acting upon all metals. Some metals are eafily and copioufly diffolved by oils, and perhaps they might all be found to be entirely foluble in oils, if the methods known in chemiftry were tried for the accomplifhment of thefe folutions.

The properties above-mentioned agree in general to all metallic fubftances: but, befides the properties peculiar to each metal, fome properties are common to a certain number of them; and hence they have been divided into feveral claffes.

Thofe metallic matters which, when ftruck by a hammer, or ftrongly compreffed, are extended, lengthened, and flattened, without being broken, (which property is called *ductility* or *malleability*) and which alfo remain fixed in the moft violent and long continued fire, without diminution of weight, or other fenfible alteration, are called *perfect metals*. Thefe perfect metals are three; *gold*, *filver*, *platina*.

The metallic matters which are ductile and fixed in the fire, to a certain degree, but which are deftroyed by the continued action of fire, that is, changed into an earth deprived of all the characteriftic properties of metals, are called *imperfect metals*. Of this kind are four; *copper*, *iron*, *tin*, *lead*.

The metallic fubftances which, as well as the imperfect metals, lofe their metallic properties by expofure to fire, but which alfo have no ductility nor fixity, are diftinguifhed from the others by the name of *femi-metals*. Of this clafs are five; *regulus of antimony*, *bifmuth*, *zinc*, *regulus of cobalt*, and *regulus of arfenic*.

Laftly, mercury, which has all the general properties of metals, makes a clafs feparate from the others; becaufe in purity and gravity it is fimilar to the perfect metals, and in volatility to the femi-metals. Its fufibility alfo fo far furpaffes that of any other metallic matter, that it is fufficient to diftinguifh it from all, and to give it a diftinct clafs. We have enumerated, therefore, in all, thirteen metallic fubftances, two of which only were unknown to the ancients

cients, namely, platina and regulus of cobalt. We have reaſon to wonder that theſe two metallic bodies, and particularly platina, which is a perfect metal, ſhould have remained unknown till lately.

This may give us cauſe to hope, that if natural hiſtory and chemiſtry be carefully cultivated, as they have been ſince the renovation of the ſciences, we may ſtill make eſſential diſcoveries in this way.. Mr. Cronſtedt has given, in the Swediſh Memoirs, a deſcription of a metallic matter, which, as he ſays, appears to be a new ſemimetal diſtinct from the others. In that caſe, this would be the fourteenth metallic matter known, and the third lately diſcovered: but as, ſince the Memoir of Mr. Cronſtedt, this new ſemimetal has not been examined by chemiſts, it is yet but little known; and therefore further experiments ſeem requiſite to decide whether it ought to be admitted as a new ſemimetal. *(y)*

As chemiſts can only know compound bodies by being capable of ſeparating the principles of ſuch bodies, and even of re-uniting their principles ſo as to reproduce ſuch compounds as they were originally; and as hitherto they have not been able to accompliſh any ſuch decompoſition upon the perfect metals; hence, if all the other metallic ſubſtances were equally inalterable, we ſhould be very far from having certain notions concerning metals in general: but if we except gold, ſilver, and platina, all the other metallic matters are ſuſceptible of decompoſition and of recompoſition, at leaſt to a certain degree; and the experiments of this kind made by chemiſts, and chiefly by the modern chemiſts, have thrown much light on this important ſubject.

We may obſerve, that even if we had not been able to decompoſe any metallic ſubſtance, we might ſtill, by reflecting on the eſſential properties of metals, diſcover ſufficiently well the nature of their principles.

The ſolidity, the conſiſtence, and eſpecially the gravity which they poſſeſs in a degree ſo ſuperior to all other bodies, would not have allowed us to doubt that the earthy element, of which theſe are the characteriſtical properties, enters largely into their compoſition, and makes their baſis.

The facility with which they combine with almoſt all inflammable matters, and with all thoſe which have great affinity with phlogiſton, ſuch as acids; joined to their incapacity of being allayed with meagre matters that are purely earthy or purely watery, which have no diſpoſition to unite with phlogiſton; would alſo have furniſhed very ſtrong motives to believe, that the inflammable principle enters largely into the compoſition of metals.

We muſt acknowledge, however, that theſe conſiderations would only have furniſhed concerning the exiſtence of the inflammable principle in metals, but a ſimple probability, very far from the compleat proof we now have: but the combuſtibility of all metals capable of decompoſition by this method, and of a ſubſequent reduction with all their properties, by the rejunction of the inflammable principle, furniſhes the cleareſt and the moſt ſatisfactory demonſtration that we have in chemiſtry. We ſhall now mention what is known upon this ſubject, and the conſequences neceſſarily reſulting.

(y) See NICKEL. Mr. *Juſti* pretends that he has diſcovered a new metallic ſubſtance contained in yellow mica. This he ſays was of a blackiſh-grey color; but when mixed with gold heightened the luſtre, without deſtroying the malleabity of that metal, though itſelf is brittle.

The deſtructible metals preſent exactly the ſame phenomena as all other bodies containing the inflammable principle do, in the ſtate of combuſtion. When expoſed to fire, without acceſs of air, that is, in cloſe veſſels, they become red-hot, melt, or ſublime, according to their nature: but they receive no alteration in their compoſition from fire applied in this manner, and they are afterwards found to be exactly in the ſame ſtate as before. In this reſpect, they reſemble perfectly all bodies which contain no other inflammable matter than pure phlogiſton.

But when imperfect metals are expoſed to fire, with acceſs of air, as, for inſtance, under a muffle in a furnace which is made very hot, then they burn more or leſs ſenſibly, as their inflammable principle is more or leſs abundant, or more or leſs combined. Some of them, as iron and zinc, burn with a very lively and brilliant flame; but this flame is of the ſame nature as that of charcoal, of ſulphur, of all bodies, the combuſtible principle of which is pure phlogiſton, and is not in an oily ſtate, that is, furniſhes no ſoot capable of blackening.

Alſo the imperfect metals detonate with nitre, when all the circumſtances which that detonation requires are united. *See* Detonation *of* Nitre. Their phlogiſton is conſumed by this method much more quickly and compleatly than by ordinary calcination or combuſtion. Their flame is alſo much more lively and brilliant; and ſome of them, as iron and zinc, are uſed in compoſitions for fireworks, from their very vivid and beautiful flame.

Nitre is alkaliſed by theſe metallic detonations exactly in the ſame manner as in its detonation by coals.

Laſtly, imperfect metals being treated with acids which have an affinity with phlogiſton, that is, with the vitriolic and nitrous acids, are deprived alſo by theſe acids of a more or leſs conſiderable part of their inflammable principle: They give a ſulphureous quality to vitriolic acid, and are even capable of furniſhing ſulphur with that acid.

Although the experiments now mentioned were the only proofs of the exiſtence of an inflammable principle in metallic ſubſtances, theſe would be ſufficient to eſtabliſh it inconteſtibly. But we ſhall ſee, when we continue to examine the phenomena attending the decompoſition of metals, that thoſe are not the only proofs.

If the inflammable matter which ſhews itſelf ſo evidently in the burning of metals, is really one of their conſtituent parts, their eſſential properties muſt be altered in proportion to the quantity of it taken from them; and this evidently happens upon trial; for the reſiduum of metallic matters, after calcination, departs from the metallic character, and approaches to the nature of mere earth. The opacity, brilliancy, ductility, gravity, fuſibility, volatility, in a word, all the properties by which metallic ſubſtances differ from ſimple earths, diminiſh or entirely diſappear, by taking from them their inflammable principle; ſo that when their calcination has been carried as far as is poſſible, they reſemble mere earths, and have no longer any thing in common with metals. Theſe earths can no longer be combined with acids or with metals, but are capable of uniting with pure earths. They are then called *calxes* or *metallic earths*. *See* Calxes (Metallic).

We must observe concerning the decomposition of metals, 1. That when only a small quantity of inflammable principle is taken from metals, a small quantity only of calx is formed, and the remaining part continues in the metallic state: hence, as the portion of calcined metal can no longer remain united with the undestroyed metal, it separates in form of scales from the surface of the metal, when the calcination has been performed without fusion, as generally happens to iron and to copper; or these scales float upon the surface of the melted metal when the calcination is performed during fusion, because the calx is specifically lighter than the metal, as happens to the very fusible metals, as tin, lead, and most of the semimetals.

2. The imperfect metals are not all equally easily and compleatly calcinable. In general, as much of their phlogiston may be easily taken from them, as is sufficient to deprive them of their metallic properties; but the remaining portion of their phlogiston cannot so easily be driven from them. Some of them, as copper, resist the first calcination more than the rest; and others, as lead and bismuth, may be very easily calcined, but only to a certain degree, and retain always obstinately the last portions of their inflammable principle; lastly, others, as tin and regulus of antimony, may not only be easily and quickly calcined, but also much more completely. All the other metals partake more or less of these properties relating to their calcination. In general, if we except the labors of alchemists, which are not much to be depended upon, we have not yet made all the proper efforts to arrive at a perfect calcination of the several metallic substances; which, however, is absolutely necessary, before we can arrive at a complete knowledge of the nature of their earths, as we shall afterwards see.

When metallic earths have lost but little of their phlogiston, and are exposed to strong fire, they melt and are reduced to compact masses, still heavy and opake, although much less so than the metals, and always brittle and absolutely unmalleable. If the calcination has been more perfect, the metallic earths are still fusible by fire, but less easily, and convertible into brittle and transparent masses possessed of all the properties of glass, and are accordingly called *metallic glasses.* These glasses do not possess any of the properties of their metals, excepting that they are specifically heavier than other glasses, that they are capable of being attacked by acids, and that the glasses of the semimetals are somewhat less fixed than unmetallic glasses. Lastly, when the calcination of metals has been carried to its greatest height, their earths are absolutely fixed, and unfusible in the fire of our furnaces, and possess no longer the solubility in acids by which metals are characterised.

These are the principal changes which metals suffer by losing their phlogiston. They are thus changed into substances which have no properties but those of earth. This is a certain proof that the inflammable principle is one of their constituent parts. But we have also other proofs of this important truth. The reduction of metallic calxes into metal, by the addition of phlogiston alone, completes the proof; and the whole forms one of the clearest and most satisfactory demonstrations in all the sciences. This reduction is effected in the following manner.

If the earth of a metal be mixed with any inflammable matter, which either is, or can be changed into the state of coal, together with some salt capable of

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facilitating fusion, but which, from its quantity or quality, is incapable of receiving the inflammable principle; and if the whole be put into a crucible, and the fusion promoted by a fire gradually raised; then an effervescence will happen, accompanied with a hissing noise, which continues a certain time, during which the fire is not to be encreased; afterwards, when the whole has been well fused, and the crucible taken from the fire and cooled, we shall find at the bottom, upon breaking it, the metal, the earth of which was employed for the operation, possessed of all the properties which it had before calcination and reduction. *See* REDUCTION.

We cannot doubt that this wonderful transformation of an earthy substance into a metal is solely caused by the phlogiston passing from the inflammable matter to the metallic earth; for, first, in whatever manner, and with whatever substance metallic earths be treated, they cannot be ever reduced into metals without a concurrence of some substance containing phlogiston. 2dly, The nature of the substance which is to furnish phlogiston is quite indifferent, because this principle is the same in all bodies containing it. 3. Lastly, if after the operation the substance furnishing the phlogiston be examined, we shall find that it has lost as much of that principle as the metallic earth has received

The facts related concerning the decomposition and the recomposition of metals prove incontestably, that they are all composed of earth and phlogiston. But we do not yet certainly know whether these two be the only principles of metals. We might affirm this, if we could produce metals by combining phlogiston with some matter which is certainly known to be simple earth. But this hitherto has not been accomplished; for if we try to treat any earth, which has never been metallic, with inflammable matters, we shall perceive that these simple earths are not combinable with phlogiston, so as to form metals. We shall even perceive that the metallic earths resist this combination, and are incapable of reduction into metal, when they have been so much calcined as very nearly to approximate the nature of simple earths.

These considerations, added to this, that we cannot easily conceive how, from only two certain principles, so many very different compounds as the several metallic substances are, should result, are capable of inducing a belief that some other principle is added to these two already mentioned in the composition of metals.

Many great chemists, and particularly Becker and Stahl, seem to be convinced of this opinion; and chiefly from the experiments concerning the mercurification of metals, they believe that this third principle exists copiously in mercury; that it is of a mercurial nature; that it also exists in marine acid, to which it gives its specific character; that by extracting this mercurial principle from marine acid, or any other body containing it copiously, and by combining it with simple earths, these may acquire a metallic character, and be rendered capable of receiving phlogiston, and of being completely metallised.

These chemists admit also, and with probability, a different proportion of metallic principles in the several metals, and believe, that particularly the principle which they call *mercurial earth* exists more copiously and sensibly in certain metals than in others. The most mercurial metals, according to them, are mercury, silver, lead, and arsenic. Most chemists distinguish from the

the other metals, ſilver, mercury, and lead; which they call *white metals*, *lunar metals*, or *mercurial metals*.

All theſe conſiderations being united, and others too many to be mentioned, give ſome probability to the exiſtence of the mercurial principle in metals. We muſt however acknowledge, that the exiſtence of this principle is only merely probable, and, as Stahl obſerves, is not nearly ſo well demonſtrated as that of the inflammable principle: we may even add, that we have ſtrong motives to doubt of this exiſtence.

As marine acid, mercury, arſenic, and even the other ſubſtances in which the mercurial earth is ſuppoſed to abound, are very volatile, and that none of the properties attributed to it ſhew that it is fixed, it ſeems, if it does exiſt, to be neceſſarily volatile. The chemiſts who admit it, conſider it as volatile, ſince one of the methods beſt atteſted for the mercurification of metals is by ſubliming them through charcoal in Geber's manner, and ſince it is chiefly in the ſoot formed by the metals, that chemiſts look for their mercurial principle.

If then the mercurial earth be a volatile principle; when metals are decompoſed by combuſtion, or by detonation with nitre, a conſiderable part of this volatile mercurial principle muſt be diſſipated. Hence we ought not to be able to remetalliſe the calxes of metals, without recombining not only their loſt phlogiſton, but alſo their loſt mercurial earth. But from experience we know, that by addition of phlogiſton alone theſe calxes may be metalliſed, and that no mercurial principle is neceſſary. We cannot anſwer to this difficulty, that all ſubſtances containing phlogiſton contain alſo a ſufficient quantity of mercurial earth for the reduction of metallic calxes; for if that were true, we ſhould be able to produce metals by treating unmetallic earths with inflammable matters, ſince in ſuch a combination all the principles of metals would be preſent. But we have already obſerved, that this cannot be done.

When indeed metallic calxes are reduced, there is always ſome loſs of quantity, as the ſame weight of metal is never procured which exiſted previouſly to the calcination; and alſo the more complete the calcination has been, this loſs of weight will be ſo much the more conſiderable. We may conſequently attribute this loſs to that of the mercurial principle, during the decompoſition of the metal, and which is not reſtored to it by reduction with phlogiſton alone.

But may we not as reaſonably believe, that if ordinary earths, or even metallic earths perfectly calcined, cannot be metalliſed, this proceeds only from the difficulty of commencing an union with ſubſtances ſo different as earth and phlogiſton? but when this union is once begun by nature, the earth is then much more diſpoſed to combine intimately with a ſufficient quantity of phlogiſton to conſtitute it a metal; that thus any earth, entirely free from phlogiſton intimately combined, is, relatively to us, an unmetallic earth, whether it be naturally found in that ſtate, as almoſt all ſubſtances are, which we call ſimply *earths*, or whether it be a metallic ſubſtance perfectly calcined. Hence the mercurial earth would be nothing elſe than phlogiſton, or rather is not a diſtinct ſubſtance, ſince it conſiſts only in a beginning of union of phlogiſton with earth, or in a diſpoſition which an earth has of uniting intimately with the inflammable principle. This is an idea of the celebrated Henkel, whom

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we certainly cannot suspect of indifference or incredulity concerning the possibility of the artificial production of metals.

If this opinion were well grounded and proved, the artificial production of metals would be, in fact, not only possible, but much less difficult than has hitherto been believed; for only two principles are, in this case, necessary to be combined to form a metal. We should then have nothing to do with the mercurial principle, the most troublesome of all, the most untractable, the least distinctly known, and the existence of which is not even ascertained.

But notwithstanding these considerations, we must not believe that the production of metals is not one of the most difficult problems in chemistry. The reflexions we shall add upon this subject will be sufficient demonstration to every sensible person, that great knowledge is requisite in that science, to attempt with any hopes of success, the production even of the most imperfect semimetal; they will shew the folly of those who attempt to make gold and silver, without being possessed of any knowledge even of elementary chemistry, which they despise and call *vulgar chemistry*, of which they disdain to inform themselves, although elementary knowledge be in chemistry, as in every other science, the most essential, fundamental, and necessary for further attainments. By a singular fatality, the most ignorant persons are the most presuming. They who see what passes in the particular assemblies of the Academy of Sciences, know that this illustrious society is always beset with pretenders to geometry, who really believe they have discovered the quadrature of a circle, the perpetual motion, &c. and who at the same time are so ignorant of the first elements of algebra and geometry, that they are incapable of perceiving the demonstrations of their errors. Happily the persons who imagine that they have discovered the means of making gold, are not so communicative, and keep their secrets in hopes of enriching themselves, otherwise the Academy would be as much importuned by the adepts of the philosophers stone, as it is now by the squarers of a circle.

To return to the artificial production of metals, we must observe, that even if we were certain, that it depends only on the intimate combination of the inflammable principle with a matter simply earthy, we should labor by chance, and without any reasonable expectation of success, if we were to attempt that combination, without having more knowledge than we now possess, concerning the true nature of the earthy principle which enters into the composition of metals; for we must acknowledge that chemistry has made but little progress in this matter.

Metallic substances, although they resemble each other by the general properties mentioned in the beginning of this article, differ nevertheless from each other very evidently by the properties peculiar to each. Do these differences proceed from the different proportion, and from the more or less intimate connexion of the inflammable principle with the earthy principle, supposing that this latter should be essentially the same in all metals? or ought they to be attributed to the difference of earths, which, in that case, would be distinct and peculiar to each metal? or, lastly, do metals differ from each other, both by the nature of their earths, and by the proportion and intimacy of connexion of their principles? All these things are entirely unknown, and we may easily perceive, that till they are known, we cannot discover what method to pursue

pursue in our attempts to accomplish the combinations we are now treating of.

The most essential point then is to arrive at a knowledge of the true nature of the earths which are in metals; and the only method of arriving at this knowledge is, to reduce them to their greatest simplicity by a perfect calcination. But this cannot be accomplished but by long and difficult operations. We have seen above, that all metals are not calcinable with equal ease; that the perfect metals have not been hitherto calcined truly, by any process; and that in general the last portions of phlogiston adhere very strongly to calcinable metals.

Some metals, however, as tin and regulus of antimony, may be easily calcined so as to be rendered irreducible. By carrying the calcination still further, by the methods known in chemistry, we might obtain their earths so pure, that all their essential properties may be discovered, by which they might easily be compared together. This comparison would decide whether their nature be essentially different, or not.

If they were found to be composed of earths essentially the same, we might next proceed to compare metallic with unmetallic earths. If the former were found similar to some of the latter kind, we should be then assured that the earth of metals is not peculiar to them, and that ordinary unmetallic earths are susceptible of metallisation.

The greater the number of metals operated upon, the more general and certain the consequences resulting from these would be; so that, for instance, if the operation were extended to all calcinable metals, and if the result of each of these operations were, that the calxes, when perfectly dephlogisticated, do not differ from each other, and are similar to earths already known, we might conclude from analogy, and we should be almost certain, that the earths of the perfect metals are also of the same nature.

They who know the extent and difficulties of chemical operations, will easily perceive that this would be one of the most considerable. Nevertheless, after having determined this essential point, we should only have done half our work. For a knowledge of the nature of the earth of metals, and where it is to be found, would not be sufficient; we must further endeavor to find a method of combining with this earth a sufficient quantity of phlogiston, and in a manner sufficiently intimate, that a metal might be formed by such a combination. We here always suppose, that earth and phlogiston are the two only principles of metals. I say, then, that the method of combining these two principles must be discovered; for we know that the ordinary processes, those, for example, which are employed for the reduction of metals, are insufficient in this case. But this second difficulty is perhaps greater than the former.

When we reflect on the fundamental rules of the union of bodies, we shall discover a road which may lead to this combination. In fact, if it be true, as every thing seems to demonstrate, that all natural substances may be united together, and that the resistance made by some to this union proceeds from the too strong union of their integrant parts, then the difficulties which occur in attempting to combine intimately phlogiston with earth, which of all known substances has the strongest aggregation, can only proceed from the too great adhesion

hesion of the integrant parts of earth to each other. Hence the only method of disposing to this union, is to separate and insulate the primary integrant parts sufficiently, and to break the aggregation as much as is possible.

The integrant parts of earth may indeed be well disjoined, when fused by a strong heat: therefore, if it were possible to fuse perfectly a simple earth, previously mixed with some inflammable matter, and put into a vessel accurately closed (which circumstance is absolutely necessary to prevent the combustion of the inflammable principle) the phlogiston would probably unite intimately with this earth, and a metallic matter would result from it. But this method seems to be impracticable, because simple earths are too refractory to be fused without addition, by the strongest fire which can be made in furnaces.

We may indeed facilitate, as much as we please, the fusion of earths, by the addition of saline fluxes; but this method, which succeeds very well for the reduction of metallic earths, when they have not been too much dephlogisticated, and when therefore they preserve a disposition to be metallized, becomes insufficient to reduce these earths, when they have been too much calcined; and it must be much more insufficient with regard to simple earths, which have never been in a metallic state.

The reason of this is, that to procure the union of one body with another, not only the aggregation of that body must be broken, but also when this disjunction of aggregation is occasioned or facilitated, as in the present case, by the interposition of the parts of some substance, this substance must not have a too great affinity with the body to be united to that whose aggregation is broken, as may easily be understood.

But we are certain that all the saline matters, which may be employed to facilitate the fusion of earths, have themselves a very great affinity with the inflammable principle; and the greater this affinity is, the more it ought to weaken the tendency which the inflammable principle has to be combined with the parts of earth.

Here then is a compensation. For if, on one side, the salts, while they facilitate the fusion of the earth, place it in a more favorable state for combination with phlogiston; on the other side, the affinity of these salts with phlogiston diminishes in the same proportion the disposition which the phlogiston has of combining with the earth; and therefore we need not wonder that this combination should not take place.

But the case is different, when the earth intended to be metallised by the addition of phlogiston, is previously united intimately with a certain quantity of that principle, as happens in metallic calxes not perfectly dephlogisticated. For this phlogiston, strictly united with the earth, not only much diminishes the force of its aggregation, but it must also necessarily facilitate very greatly the accretion of a new quantity of phlogiston, from the strong disposition of bodies to unite with others of the same nature.

Hence we cannot hope to succeed in trials of this kind by fusion with an intense fire: but these are not the only resources which chemistry offers to us. We are very certain, that the metallic combinations formed daily by nature, are not effected by violent fusions. Water kept in a fluid state by the little heat necessary for that purpose, is itself capable of keeping the integrant parts of bodies

bodies whose aggregation is broken, suspended and insulated from each other, and those of earth, as well as of other substances, as is evidently demonstrated by sediments, stalactites, crystallizations, stones of all sorts, which are formed every where by water. Water also of all substances has the least affinity with phlogiston, and consequently has all the requisite conditions as a vehicle, to assist the combination of earth with phlogiston: Lastly, we know from experience that metals may be decomposed, and that their calxes may be metallised as well by the humid as by the dry way. *See* REDUCTION.

Water, then, seems to be a very proper intermediate substance to form the first rudiments of metallisation, and is employed by nature for the production of metals, minerals, and of all the compound bodies that we see. According to the opinion of one of our greatest naturalists and philosophers, nature makes with water all that we make in our laboratories with fire, and many others which we cannot accomplish. Water is her principal and almost only instrument. By water, therefore, that is, by the humid way, the combinations now in question ought to be attempted.

But, it may be said, nature employs an almost infinitely long time for most of her productions, and particularly for metallic combinations. Can this time be shortened by chemical means? Does chemistry furnish a method of impregnating water with the primitive integrant molecules of earth, and with a sufficient quantity of inflammable principle? We have reason to presume it. Nevertheless, to be able to affirm any thing upon this subject, a person ought to have made experiments with these views; which, I confess, I never have done.

We shall not enter into a further detail upon this matter, that we may not prolong this discussion, perhaps too long already, and too conjectural for a work of this nature. We thought some extent ought to be given to it, not only because the subject is itself interesting, but also because many persons, particularly those who are ignorant of the whole extent of chemistry, consider metallisation as the sole object of that science. It has been almost the sole end of chemists, from time immemorial to the renovation of the sciences, that is, to late times.

All the ancient chemists were solely engaged about metals. Their views and inquiries were so directed to that point, that they entirely neglected whatever was not connected with it; so that the name of chemist gave the idea of a man who endeavored to make metals. The insuperable obstacles they have met, have obliged them to multiply their experiments, and to work upon many bodies besides metals. The properties of many substances have been thus discovered successively; and these multiplied discoveries, having been afterwards generalised, and arranged, have given birth to the philosophical chemistry now cultivated; to that chemistry which explains clearly, which proceeds with order and method, and which in this respect differs greatly from the ancient researches concerning the philosopher's stone.

We do not now undertake with the same confidence and ardor as heretofore the solution of the most difficult problems. The slow and circumspect progress of chemistry appears humble and timid, in comparison of the bold and rapid course of ancient alchemy: but such is the consequence of experience and reflection.

When men have long wandered at random; when, after they have fatigued themselves with every trial that occurred, without rule or measure, they have failed in their attempts; their most reasonable conduct is to return as they came, to begin afresh, and not to engage in the pursuit till the proper road be well ascertained.

We do not consider as certain guides the ideas which the nature of the subject, and the desire of contributing to the advancement of the art, and of inspiring a true taste for it, have induced us to suggest on metallisation in this article. If, in pursuing these ideas, we should be able to produce the rudest beginning of a metal or semimetal, true chemists would certainly find much cause of astonishment and admiration. Much farther are we from presuming that by this method the perfect metals, as gold and silver, can be produced. We do not intend to excite too flattering hopes, but only to present a rational plan of such labors, and to shew the difficulties to those who chuse to undertake them.

We ought to advertise here, that some famous chemical processes have been considered by many as metallisations, but which are really not so. Such is Beccher's famous experiment of the *Minera arenaria perpetua*, by which that chemist proposed to the States General to extract gold from any kind of sand. Such also is the process of Beccher and of Geoffroy, to obtain iron from all clays by treating them with linseed oil in close vessels. In these, and many other such processes, we do only obtain metal that was already formed. Every earth and sand, as the intelligent and judicious Cramer observes, contain some particles of gold. Clays do not commonly contain iron ready formed, but all of them contain a ferruginous earth, naturally disposed to metallisation. See CLAY. Accordingly we must conclude, that, by Mr. Geoffroy's experiment, iron is only reduced or revived, but is not produced.

The great difficulties which occur in attempting to give a metallic quality to simple earths have induced a belief, that the nature of metals ready formed might be more easily changed, and the less perfect brought to a more perfect state. To effect this, which is one of the principal objects of alchemy, and is called transmutation, numberless trials have been made. As we have not any certain knowledge of what occasions the specific differences of metallic substances, we cannot decide whether transmutation be possible or not. In fact, if each metallic substance have its peculiar earth, essentially different from the earths of the others, and consequently if the differences of metals proceed from the differences of their earths; then, as we cannot change the essential properties of any simple substance, transmutation of metals must be impossible. But if the earths and other principles of metals be essentially the same, if they be combined in different proportions only, and more or less strictly united, and if this be the only cause of the specific difference of metals, we then see no impossibility in their transmutation.

Whatever be the cause of the differences of metals, their transmutation seems to be no less difficult than the production of a new metallic substance; and perhaps it is even more difficult. Alchemists, whom nothing astonishes or embarrasses, believe that transmutation is possible, and they even affirm that they have effected it. They begin by supposing that all metals are composed of the same principles, and that the imperfect metals do not differ from gold and silver,

but becauſe their principles are not ſo well combined, or becauſe they contain heterogeneous matters. We have then only theſe two faults to remedy, which, as they ſay, may be done by a proper coction, and by ſeparating the pure from the impure. As we have but very vague and ſuperficial notions concerning the cauſes of the differences of metals, we confeſs that we cannot make any reaſonable conjecture upon this matter; and we ſhall only adviſe thoſe who would proceed upon good principles, to determine previouſly, if metals have each a peculiar earth, or only one common to them all. In the ſecond place, if it ſhould be demonſtrated that the earthy principle is the ſame in all metals, and if that be demonſtrated as clearly as the identity of the inflammable principle in metals is proved; they muſt then determine whether theſe two be the only principles in metals, whether the mercurial principle exiſts, and whether it be eſſential to all metals, or to ſome only, and what is the proportion of theſe two or three principles in the ſeveral metallic ſubſtances. When we ſhall clearly underſtand theſe principal objects, we may then be able to determine concerning the poſſibility of tranſmutation; and if the poſſibility ſhould be affirmed, we ſhall then begin to diſcover the road which we ought to purſue.

We have no reaſon to believe that any other principle enters into the compoſition of metals than thoſe above-mentioned; no veſtige is perceptible of either air or water. Some chemiſts have nevertheleſs advanced that they contain a ſaline principle. If that were true, they would alſo contain a watery principle. But all the experiments adduced to prove this opinion are either falſe, or only ſhew the preſence of ſome ſaline particles extraneous to the metals, or contained unknown to the chemiſts in the ſubſtances employed in the experiments. For metals perfectly pure, ſubjected to all trials with ſubſtances which do not contain, and which cannot produce any thing ſaline, do not diſcover any ſaline property. We muſt however except arſenic, and even its regulus, theſe being ſingular ſubſtances, in which the ſaline are as ſenſible as the metallic properties.

Arſenic ſeems to be one of thoſe intermediate ſubſtances which nature has placed in almoſt all its productions betwixt two different kinds, and which partake of the properties of each kind. Arſenic thus placed betwixt metallic and ſaline ſubſtances has properties common to both theſe kinds of ſubſtances, without being either entirely a metal or a ſalt. *See* ARSENIC.

As water ſeems to act to a certain degree upon iron, even without the concurrence of air, as the operation of martial ethiops ſhews, we might thence ſuſpect ſomething ſaline in that metal. Nevertheleſs, I do not believe that what happens in that operation has been ſo well explained, that any certain conſequences can be deduced. 1. The water employed ought to be perfectly pure, that is, diſtilled rain water. 2. The iron employed ought alſo to be perfectly pure, and ſuch is very difficultly to be procured. 3. The operation ought to be performed in a bottle accurately cloſed, that we may be aſſured that the air contributes nothing to the action upon the iron. 4. After the water has remained a long time, ſuppoſe a year, upon the iron, the water ought to be carefully filtrated and examined, to aſcertain whether it really has diſſolved any part of the metal.

In the mean time, we may conclude that metals do not ſeem to contain any ſaline principle. And when we conſider well their general properties, they

ſeem to be nothing elſe than earths combined more or leſs intimately with a large quantity of phlogiſton. Although we can demonſtrate that their inflammable principle is not in an oily ſtate, and that it is pure phlogiſton, they have nevertheleſs an oily appearance, in this circumſtance, that they adhere no more than oils to earthy and aqueous ſubſtances, and that they always aſſume a globular figure when ſupported by theſe ſubſtances entirely free from phlogiſton.

This reſemblance is ſo ſenſible, that chemiſts, before they knew the nature of phlogiſton, believed that metals contained an oily and fat matter; and even now many perſons, who talk of chemiſtry without underſtanding it, ſpeak of the *oil, or fat of metals*; expreſſions, which do not ſound well to genuine chemiſts. The cauſe of this quality of metals is the quantity of phlogiſton which they contain. Sulphur, phoſphorus, oils, and even fats, have this appearance merely from the inflammable principle which enters into their compoſition: for this property is communicated by that principle to every compound which contains a certain quantity of it. *See* PHLOGISTON.

When the phlogiſton combines copiouſly and intimately with earthy matters ſo as to form metals, it probably ſo diſpoſes them that the primitive integrant parts of the new compound, that is, of the metal, approximate and touch each other much more than the integrant parts of ſimple earths can. This is proved by the great denſity or ſpecific gravity, and other general properties, of metals.

In fact, as we cannot conceive that a body ſhould be tranſparent, unleſs it have pores and interſtices through which rays of light can paſs, therefore the more denſe a body is, that is, the fewer ſuch interſtices it has, the leſs tranſparent it will be; ſo that the denſeſt bodies ought to be the moſt opake; as in metals. The diſpoſition of the pores of bodies contributes alſo much to their greater or leſs tranſparency; and bodies, the pores of which are continued and ſtreight, are more tranſparent than thoſe whoſe pores are interrupted, tranſverſe, or oblique; ſo that a body may be much more tranſparent than another which is leſs denſe; as we ſee that glaſs is more tranſparent than charcoal. But when other circumſtances are equal, the denſeſt bodies are the moſt opake. Therefore the opacity of bodies is proportionable to their denſity, and to the deviation of their pores from right and parallel lines.

From the great opacity of metals, they probably poſſeſs both theſe qualities in an eminent degree. We have ſeen, at the beginning of this article, that the luſtre of metals and their property of reflecting light much better than any other ſubſtance, are neceſſary conſequences of their opacity. This is alſo ſelf-evident, becauſe the fewer rays any bodies can tranſmit, the more it muſt reflect.

Laſtly, the ductility of metals proceeds alſo from their denſity, and from the diſpoſition of their pores, as we have explained under the word DUCTILITY. Phlogiſton alſo appears to communicate ductility to moſt of the bodies containing it, as we ſee in ſulphur, and unctuous bodies, as reſins, wax, &c. all which are more or leſs ductile, at leaſt when heated to a certain degree. Laſtly, the ſoftneſs, fuſibility, and volatility of which all metals partake more or leſs, and which many of them poſſeſs in a ſuperior degree, being properties entirely contrary to thoſe of the earthy principle, probably proceed from the inflammable principle. In general, if we reflect on the eſſential properties of the earthy and inflammable

rable principles, we shall easily perceive that these properties, being combined and nodified by each other, ought to produce the properties of metals. In order herefore to understand all this article, the words EARTH and PHLOGISTON ught to be consulted.

The order in which metals compared with each other possess most eminently heir principal properties, is the same as that in which they are here enumerated, eginning always with that metal in which the property is most considerable.

1. *Specific gravity* or *density*. Gold, platina, mercury, lead, silver, copper, ron, and tin.

2. *Opacity*. We cannot well compare metals with each other in this respect, ecause it is so considerable in all that it seems complete. If, however, they differ n this respect, the same order will serve for opacity as for density.

3. *Metallic lustre* or *brilliancy*. The same observation which was made conerning the last-mentioned property is applicable to this also. We must howver observe, that as, by polish, bodies are rendered brighter, and that as whiteness ontributes much to the reflexion of light, the whitest and hardest metals thereore reflect best. Hence platina ought to be placed first, and then iron or ather steel, silver, gold, copper, tin, lead. (z)

4. *Ductility*. Gold, silver, copper, iron, tin, lead. The ductility of mercury ind of platina are not yet determined.

5. *Hardness*. Iron, platina, copper, silver, gold, tin and lead.

6. *Tenacity*. By tenacity we understand the force with which the integrant parts of metals resist their separation. This force appears to be in a compound ratio of their ductility and hardness. The comparative tenacity of metals is measured by the weight which wires of the same diameter, made of the several metals, can sustain without breaking. Gold is the most tenacious, then iron, copper, silver, tin, lead. The tenacity of mercury is unknown: That of platina is not yet determined, but is probably considerable.

7. *Fusibility*. Mercury, tin, lead, silver, gold, copper, iron, and lastly platina, which cannot be fused by the greatest fire of our furnaces, but only by the solar focus, as Messrs. Macquer and Beaumé have determined.

(z) Hardness of metals may contribute much to the duration of their polish; but certainly soft metals, if their texture be equally compact, are no less capable of receiving a polish than hard metals. Some hard metallic allays have been found to be less liable to tarnish than softer compounds, and have for this reason also been chiefly used for speculums. The property of reflecting light seems chiefly to depend on the closeness of the particles, or on the density, on the smoothness of the surface, and on the color being most similar to the color of the light to be reflected. The white metals, silver, mercury, tin, reflect light more abundantly than others. Gold being the densest metal, and perhaps because the color of solar light has a slightly-yellowish tinge, does also reflect light very copiously. Hence speculums made of leaf-gold have been found to be very effectual. Iron or steel reflects much less light than any of the above-mentioned metals, although the author has considered it as capable of a greater reflective power. Platina is generally in so small grains, that its reflective power cannot easily be determined. The precise degrees of that power which ought to be assigned to each of the above-mentioned metals, cannot without accurate experiments be ascertained. However, I think, their reflective powers will be found to be more nearly in the following order, than in that mentioned in the text. Silver, quicksilver, tin, gold, copper, iron, lead.

The

The table of affinities of Mr. Geoffroy gives for metallic ſubſtances in general, marine acid, vitriolic acid, nitrous acid, vegetable acid. Mr. Gellert's table contains no column for metallic ſubſtances in general.

The uſes of metals are numberleſs and great. Their particular uſes ſhall be mentioned under the articles of the ſeveral metallic ſubſtances.

CCCCL. M I C A. (a)

CCCCLI. M I L F O I L. (b)

CCCCLII. M I L K, *and* W H E Y. The milk of animals is a white liquor compoſed of three very different ſubſtances, namely, butter, cheeſe, and whey. Theſe three matters are intimately mixed with each other in freſh milk. Whey is the only fluid part of milk. Butter and cheeſe, which are mixed with it, have each of them a certain ſolidity, and are not ſoluble by whey. Theſe two matters, the former of which is entirely of an oily nature, and the ſecond is gelatinous or mucilaginous, are only interpoſed and ſuſpended in the ſerous part by being very much divided.

Hence we ſee that milk is a true emulſion. Butter compoſes its oily part, which by the interpoſition of its particles gives an opake white color; the cheeſe ſerves as a mucilage to keep the oily part ſuſpended; and, laſtly, whey, which is naturally tranſparent, is the aqueous ſubſtance, which is a vehicle for the other two. Milk may then be juſtly called an animal emulſion. From its properties we ſhall ſee that this name ſuits it in every reſpect.

Milk, recently taken from a frugivorous animal in good health, and fed with proper aliments, gives not by chemical trials any marks of an acid or alkaline quality. It has a ſweet, agreeable, and ſomewhat ſaccharine taſte; it contains no parts that are volatile with the heat of boiling water, at leaſt in any ſenſible quantity, ſo as to be collected. Its ſmell, which is peculiar to it, is very weak.

This liquor is very ſuſceptible of alteration; the ſmalleſt quantity of acid is capable of coagulating it. When an alkali is mixed with it, a kind of coagulation happens, which is very different from that which is occaſioned by an acid.

(a) Mica, or *Talk*, is an earthy or ſtony ſubſtance conſiſting of thin, flexible, ſhining plates. Theſe plates by expoſure to fire become brittle, crumple, and by violent heat are vitreſcible. *See* Mr. D'Arcet's Memoir on the effects of a long and violent fire. Mica is either colorleſs and tranſparent; or it is colored, red, brown, green, or black, and ſemi-tranſparent. The colored micas generally contain ſome metallic matters, chiefly iron, and as Mr. Juſti ſays, a new metallic ſubſtance [*ſee the laſt note* (y)], and are much more fuſible than thoſe which are pure and colorleſs. Micas have a ſoft touch reſembling that of unctuous ſubſtances. They are not ſoluble by acids, they are incapable of eliciting ſparks when ſtruck by ſteel, as flints do, or of forming a tenacious paſte with water, as clay does; or of hardening, when mixed with water, as gypſum does. Mica is therefore neither a calcareous, ſiliceous, argillaceous, nor gypſeous earth. The colorleſs tranſparent mica, called *Muſcovite-glaſs*, is uſed as panes for windows. In Jemptland, a crumpled kind of mica is manufactured into kettles and other veſſels, and alſo for hearths.* The powder of this ſtone is mixed with ſea-ſalt, and from the mixture marine acid is obtained by diſtillation.

(b) Milfoil, or Yarrow. The flowers and tops of the common purpliſh-flowered milfoil afford a blue oil ſimilar to that of camomile. Theſe flowers have an aromatic and not diſagreeable ſmell, and ſomewhat of a rough, bitter and pungent taſte. The bitterneſs and aſtringency remain in the extracts made by water or by ſpirit. From an ounce of milfoil-tops, water extracted three drams and a ſcruple, and ſpirit extracted from the ſame quantity two drams and a half. *Neuman.*

This

This difference proceeds from the action of the alkali upon all the parts of the milk, and especially upon the butyraceous part, to which it gives a saponaceous quality.

Milk also very readily suffers several remarkable changes, without addition of other substance. The oily or butyraceous parts of the milk, being specifically lighter than the rest, and adhering but weakly, separate in great quantity by rest alone, and are collected on the surface, precisely as the oily parts separate from emulsions. They there form what is called *cream*, from which, when collected, butter is made. Milk is also susceptible of a spontaneous fermentation, by which it becomes acid, and is coagulated.

The coagulation of milk occasions a distinct separation of the caseous part from the serous; and as this latter continues to separate, the former acquires a greater solidity. By coagulation then, these two parts of milk are obtained separately from each other. But the manner, in which this coagulation is made, produces considerable differences in the qualities of both. Wherefore milk is coagulated by different methods, according to the purposes for which the cheese and the whey are intended.

As the acid, which discovers itself in the milk when it curdles spontaneously, is more than is sufficient for its coagulation, and as it communicates its taste both to the cheese and to the whey, milk is not generally left to curdle spontaneously, either for the making of cheese for aliment, or of whey for medicine. This sensible acidity is avoided, by mixing with the milk, before it has become too old, the smallest quantity of acid necessary for coagulation, and by accelerating this coagulation by a convenient heat.

The common and also the best method is to dilute, in three or four spoonfuls of water, about 18 grains of runnet for every two pounds of milk, and to mix it with the milk, which is then to be placed upon hot embers. The milk, by means of this runnet, curdles more or less quickly according to the degree of heat given to it. When the curd is intended to be eaten before the whey is separated, the heat ought to be very gentle, and the coagulation slow. If cheese be intended to be made of it, more expedition may be used; and as soon as the milk is curdled, it is to be cut, to allow the whey to separate from it by draining. If this be done for the sake of the whey, more heat may be given, and the separation may be more expeditious. It is then to be passed through a strainer.

The butyraceous, caseous, and serous parts are separated by these operations only imperfectly. Each of these three matters partakes of the other two. The butter and the cheese are purified in the manners mentioned under their particular articles. The whey must be cleared from the caseous particles it contains, and which had not been curdled sufficiently, by throwing in and mixing well with it a liquor made by boiling about 15 grains of cream of tartar in water, and also the white of an egg; after which the whey is to be filtered through brown paper.

The runnet employed to curdle milk is nothing else than a milky matter found in the stomachs of calves. This matter is usually salted that it may be kept. It smells of old cheese, and coagulates milk, because it contains a sufficient but not sensible quantity of acid. It is a kind of leaven capable of producing the acid fermentation of milk. The same may be said of several other substances, such as the flowers of almost all thistles, of wall-flower,

hence called curdle-milk, &c. All these matters which do not seem acid, and which do not communicate any sensible acidity to milk, curdle it very well, undoubtedly from the latent acid which they contain. The operation for clarifying whey is necessary, because it could not otherwise be filtered from the caseous particles adhering to it, which must be curdled again, or more strongly by boiling with the cream of tartar and white of an egg. *See* FILTRATION.

Well clarified whey is very far from being a pure phlegm. It is indeed the most watery part of the milk, but it is also impregnated with all the parts of the milk which are soluble in water. It has accordingly a sensible taste, which becomes very evident, when the whey is evaporated to nearly one half of its quantity. It is saccharine and somewhat saltish. In whey is contained dissolved a considerable quantity of extractive substance of the nature of saccharine juices, and it is accordingly susceptible of the spirituous fermentation. The Tartars certainly make from it a spirituous drink, or kind of wine.

Whey contains, besides this saccharine fermentable substance, several kinds of salts which may be obtained by crystallization. If three fourths of clarified whey be evaporated, and if the remainder be then set in a cool place, a certain quantity of reddish crystals will be formed. This is the essential salt of milk. It is called the *sugar of milk*, from its taste, which is manifestly saccharine. But this color and taste are extraneous to the salt, and proceed from the extractive matter of the liquor in which the salt was crystallized. Accordingly, if the crystals are well drained, dissolved in pure water, and crystallized, they will be much whiter and less saccharine. By repeating the operation a third or a fourth time, the crystals may be rendered perfectly white and almost tasteless.

This salt is of a singular nature, but is little known, because it has not been well examined. We know only that it is not deliquescent, and requires much water to dissolve it. Mr. Beaumé has promised in his Pharmacy, that he will publish some particulars relative to this subject, which cannot fail of being interesting.

The liquor which furnished these first crystals contains also some more, which may be obtained by continuing the evaporation and crystallization. If the evaporation be still continued after the formation of the second crystals, some common salt will be formed; and lastly the mother-water contains, as Mr. Beaumé affirms in his Pharmacy, some fixed alkali, which consequently is obtained without burning. As this alkali is not sensible either in milk or in whey before the above-mentioned operations, it probably exists in the milk, combined with some matter with which it is saturated, and which is separated from it by these operations. All this requires a further and more particular inquiry.

Milk, and consequently whey, contains no principle more volatile than water, and therefore none of its other principles are lost by exposure to the heat of boiling water. But if we distill in a naked fire the residuum of whey, evaporated in a sand-bath to dryness, as Mr. Geoffroy has done, phlegm will be at first obtained, then a citron-colored acid spirit, and afterwards a thickish oil: lastly, a residuous coal will remain in the retort, which will become moist by exposure to air, from the saline substances with which it is mixed.

What we have said concerning whey, together with the explanations we have given under the articles, BUTTER *of* MILK, and CHEESE, are sufficient

to give juſt notions concerning the nature of milk. The reſult is, that milk is a mixture, firſt, of butter, which is an uncombined oleaginous matter, of the nature of fat, and not volatile, ſweet oils (*ſee* OIL); ſecondly, of cheeſe, which is a more earthy matter, containing oil combined nearly in a mucilaginous ſtate; and, thirdly, of whey, which is a watery liquor containing ſeveral ſalts, together with a ſaponaceous ſubſtance, or oil combined in the ſame manner as the oils of ſaccharine juices.

Milk is much employed in aliments and in medicine. It is ſoftening, incraſſating, cooling, reſtorative, and healing. It is proper againſt a ſharpneſs of humors, as tetters, eryſipelas, or gout, when theſe diſeaſes are not accompanied with fever; and againſt internal ſuppurations, phthiſis, maraſmus, and ſlow fevers. Sick perſons are frequently dieted with milk alone, and generally with good effect. But we muſt obſerve, that although milk be a food already prepared by nature, and as it were half-digeſted, it does not agree with all conſtitutions. It is apt to occaſion one of two very oppoſite diſorders, fluxes and coſtiveneſs. This is remedied by diluting it with water, or by proper correctives, or by chuſing that kind of milk which ſuits beſt with the conſtitution, and the diſeaſe to be treated. The milk of goats, for inſtance, has been obſerved to ſuit better than cows milk, with thoſe perſons whoſe conſtitution diſpoſes them to diarrheas.

Whey is not uſed as an aliment, becauſe being deprived of the butyraceous and caſeous parts of the milk which are alimentary, it is much leſs nouriſhing than milk. It affords, nevertheleſs, a little nouriſhment by means of the ſaccharine matter which it contains. Like milk, it is ſoftening and cooling, and may be employed as ſuch in the ſame diſeaſes, but it is much more diluting, aperitive and laxative. It is frequently uſed as a vehicle for other remedies.

We are far from having concerning milk all the knowledge which is to be wiſhed. Many inquiries remain yet to be made on this ſubject. For beſides the ſalt of milk, which is almoſt only known by name, nobody has hitherto undertaken a chemical examination, and a compariſon of the ſeveral kinds of milk drawn from different animals, which milks do nevertheleſs differ conſiderably from each other, as has been obſerved in the Elements of Practical Chemiſtry. Conſiderable differences muſt alſo be obſervable in the milk of the ſame animal in different circumſtances, and particularly with relation to the nature of the food which the animal has eat: for we are certain, that milk partakes much of the nature of the aliment uſed by that animal which furniſhes it. *See* CHEESE.

The milk of nurſes is well known to acquire the virtues of drugs taken by them; and thus remedies are frequently applied to children at the breaſt. (*c*)

(*c*) Thus the color of ſaffron, the bitterneſs of wormwood, and the ſmell of garlic, are given to the milk of a woman who eats theſe plants; and alſo the purgative and inebriating effects of certain ſubſtances are communicated from the nurſe to the child. Hoffman found by experiments, that the milk of cows and of goats contained more of the butyraceous and caſeous, and leſs of the ſerous and of the ſaccharine particles than human milk, and the milk of aſſes.

CCCCLIII. MILK *of* LIME. MILK *of* SULPHUR. The name of milk is given to ſubſtances very different from milk properly ſo called, and which reſemble milk only in color. Such is water in which quicklime has been ſlaked, which acquires a whiteneſs from the ſmall particles of the lime being ſuſpended in it, and has hence been called the *milk of lime*. *See* QUICKLIME. Such alſo is the ſolution of liver of ſulphur, when an acid is mixed with it, by which white particles of ſulphur are made to float in the liquor. *See* LIVER *of* SULPHUR.

CCCCLIV. MILK *of* VEGETABLES. For the ſame reaſon that milk of animals may be conſidered as a true animal emulſion, the emulſive liquors of vegetables may be called *vegetable milks*. Accordingly emulſions made with almonds are commonly called *milk of almonds*. But beſides this vegetable milk, which is in ſome meaſure artificial, many plants and trees contain naturally a large quantity of emulſive or milky juices. Such are lettuce, ſpurge, fig-tree, and the tree which furniſhes the elaſtic American reſin. The milky juices obtained from all theſe vegetables derive their whiteneſs from an oily matter, mixed and undiſſolved in a watery or mucilaginous liquor. Moſt reſinous gums were originally ſuch milky juices, which afterwards become ſolid by the evaporation of their moſt fluid and volatile parts.

Theſe natural milky juices have not been examined by any chemiſt. Such an examination would, however, procure much eſſential knowledge concerning vegetable economy. We ſhould probably find examples of all kinds of oils reduced into milky juices; and this knowledge cannot fail of throwing much light on the nature of reſins and gum-reſins. *See* GUM-RESINS *and* RESINS.

CCCCLV. MINES. *See* ORES.

CCCCLVI. MINIUM. Minium, or *red lead*, is a calx of lead, of a vivid yellowiſh red color. This color is ſaid to be given by a ſlow calcination and reverberation. Nevertheleſs, the method of making minium is not well known, as it is not made in ſmall quantities in laboratories. All the minium which is in commerce is brought from Holland, where large quantities of it are manufactured.

Minium is employed in painting, and may ſerve for all the ſame purpoſes as the other calxes of lead. *See* LEAD. *(d)*

CCCCLVII. MIRACLE (CHEMICAL). When a concentrated ſolution of fixed alkali is mixed with a ſtrong ſolution of nitre or of ſea-ſalt, with earthy baſes, the earth is ſo copiouſly precipitated, that a ſolid maſs is formed from the mixture of theſe two liquors. As this experiment is ſomething wonderful, it has been called by ſome chemiſts *miraculum chemicum*. *See* MAGNESIA.

(*d*) Minium is generally prepared by expoſing lead to a melting heat till it is converted into a greyiſh calx, which is afterwards ground, and again calcined in an oven or reverberatory furnace, during ſeveral days, with a moderate heat. The action of the flame and of air is ſaid to be neceſſary to produce the red color. For which reaſon, the matter to be calcined is frequently ſtirred during the operation, that its ſurface may be changed, and thus the whole of it expoſed to air and flame. Three parts of lead are ſaid to produce nearly four parts of minium; but if the minium be revived, about $\frac{1}{2}\frac{8}{0}$th parts only of the lead originally employed, will be recovered. A ſmaller quantity of the lead will be recovered by reduction of the minium, if the calcination has been performed more effectually.

CCCCLVIII. M I X T I O N. Stahl and all his ſchool uſe this expreſſion to ſignify the union of the firſt principles in the moſt ſimple compounds. Inſtead of it, we ſubſtitute the terms *combination* and *compoſition*; which *ſee.*

CCCCLIX. M O L Y B D E N A. *(e)*

CCCCLX. M O R T A R. A mortar is a chemical inſtrument, very uſeful for the diviſion of bodies, partly by percuſſion, and partly by grinding. Mortars have the form of an inverted bell. The matter intended to be pounded is to be put into them, and there it is to be ſtruck and bruiſed by a long inſtrument called a *peſtle.* The motion given to the peſtle ought to vary according to the nature of the ſubſtances to be pounded. Thoſe which are eaſily broken, or which are apt to fly out of the mortar, or which are hardened by the ſtroke of the peſtle, require that this inſtrument ſhould be moved circularly rather by grinding, or bruiſing, than by ſtriking. Thoſe ſubſtances which are ſoftened by the heat occaſioned by rubbing and percuſſion, require to be pounded very ſlowly. Laſtly, thoſe which are very hard, and which are not capable of being ſoftened, are eaſily pounded by repeated ſtrokes of the peſtle. They require no bruiſing but when they are brought to a certain degree of fineneſs. But theſe things are better learnt by habit and practice than by any directions.

As mortars are inſtruments which are conſtantly uſed in chemiſtry, they ought to be kept of all ſizes and materials; as of marble, copper, glaſs, iron, grittſtone, and agate. The nature of the ſubſtance to be pounded determines the choice of the kind of mortar. The hardneſs and diſſolving power of that ſubſtance are particularly to be attended to. As copper is a ſoft metal, ſoluble by almoſt all menſtruums, and hurtful to health, good artiſts have ſometime ago proſcribed the uſe of this metal. *See* Division *of* Bodies.

One of the principal inconveniences of pulveriſation in a mortar proceeds from the fine powder which riſes abundantly from ſome ſubſtances during the operation. If theſe ſubſtances be precious, the loſs will be conſiderable; and if they be

(*e*) Molybdena, or *Black lead,* is a blackiſh friable ſubſtance, unſoluble by acids, capable of reſiſting the moſt intenſe heats in cloſe veſſels. It has been generally conſidered as a talky ſubſtance, and as being apyrous: but from ſome late experiments made by Mr. Quiſt, this ſubſtance appears to be decompoſed by a calcining heat in open veſſels, and even to be almoſt entirely diſſipated or conſumed: and, long before theſe experiments, Dr. Lawſon, in his Diſſertation De Nihilo, had ſhewn that blue inflammable flowers were raiſed from black lead by a violent fire. Mr. Quiſt relates, that having expoſed ſeveral ſpecimens of this mineral to a ſtrong heat on a ſcorifying diſh under a muffle, they emitted ſulphureous fumes and flowers; that from one ſpecimen, one fifth part only of the original weight remained after calcination; and from another ſpecimen, only a twentieth part remained, of a yellow or brown calx, which being treated with inflammable fluxes, yielded ſeven-tenths of its weight of a metallic regulus, which appeared to conſiſt of iron and tin. Mr. Cronſtedt has accordingly claſſed black lead amongſt ſulphureous ſubſtances, and calls it *ſulphur ſaturated with iron and tin.*

Black lead is eaſily diſſolved or mixed with melted ſulphur; and with this mixture ſome pencils are made much inferior to thoſe which are made with ſlips of pure black-lead. Crucibles and portable furnaces are made of black-lead mixed with clay. Black lead is alſo uſed to leſſen the friction of machines, which it does from the fineneſs, the want of tenacity, and a kind of unctuoſity of its particles.

injurious to health, they may hurt the operator. These inconveniences may be remedied, either by covering the mortar with a skin, in the middle of which is a hole, through which the pestle passes; or by moistening the matter with a little water, when this addition does not injure it; or, lastly, by covering the mouth and nose of the operator with a fine cloth, to exclude this powder. Some substances, as corrosive sublimate, arsenic, calxes of lead, cantharides, euphorbium, &c. are so noxious, that all these precautions ought to be used, particularly when a large quantity of them is pounded.

Large mortars ought to be fixed upon a block of wood, so high, that the mortar shall be level with the middle of the operator. When the pestle is large and heavy, it ought to be suspended by a cord or chain fixed to a moveable pole, placed horizontally above the mortar: this pole considerably relieves the operator, because its elasticity assists the raising of the pestle.

CCCCLXI. MOTHER-WATER. *See* WATER.

CCCCLXII. MUCILAGE. Mucilage is a white, transparent substance, which has little or no taste or smell, the consistence of which is thick, ropey, tenacious, and viscid, when it is united to a certain quantity of superabundant water. It is entirely and intimately soluble in water; and it does not appear to contain any disengaged acid or alkali.

When mucilage is dissolved in a large quantity of water, it does not sensibly alter the fluidity of this liquor; but this water, by evaporation, grows more and more thick, and, lastly, acquires the viscous consistence of vegetable glue.

While the evaporation continues, the liquor becomes more and more thick, without losing any transparency; and this evaporation may be continued till the mucilage becomes quite solid: it then does not differ from gums. If this evaporation or drying has been made with a heat not exceeding that of boiling water, this mucilage, thus rendered solid, and become a gum, may be entirely dissolved again in water, and may again form a liquid mucilage, as before.

Gums or solid mucilages, when well dried and very hard, being exposed to an open fire, are not liquefied as resinous matters are; they swell, and emit many fumes, which at first are watery, then oily, fuliginous, and acrid.

This matter, at the same time, becomes black, and is then capable of being inflamed; but not before it is thoroughly dried, and almost reduced to the state of coal.

If mucilage or gum be exposed to distillation in close vessels, nothing but water is obtained, with a heat not superior to that of boiling water; and the matter which remains in the retort seems to be nearly of the same degree of dryness as before the operation; which is a certain proof that distillation does only deprive the gum of its superabundant water. If a greater degree of heat be then applied, more aqueous liquor will be obtained, which gradually becomes more and more acid and empyreumatic. By continuing the distillation with a fire gradually augmented, a little thick oil and volatile alkali pass; and, lastly, a considerable quantity of residuous coal remains in the retort, which burns difficultly in open air; together with some ashes, from which a very little fixed alkali may be obtained.

Mucilages and gums are not soluble either by oils, or by spirit of wine; which latter menstruum has the property of taking from these substances the water in which

which theyare diſſolved; ſo that if ſpirit of wine be mixed with a liquid mucilage, or with water in which gum is diſſolved, this ſpirit will take all the water of the ſolution, and will ſeparate the gummy matter in form of an almoſt dry white precipitate. We may eaſily perceive that this experiment cannot ſucceed but by adding a ſufficient quantity of ſpirit of wine, that is, a quantity proportionable to the quantity of water united with the gummy matter.

From what we have ſaid concerning the general properties of the gummy vegetable principle, we may conclude, firſt, that excepting a portion of ſuperabundant pure water, no ſubſtance is contained which is volatile with the heat of boiling water; conſequently no volatile ſaline ſpirits, no eſſential oil, or ſpiritus rector, at leaſt in any ſenſible quantity.

Secondly, we may conclude, that this gummy matter is compoſed, firſt, of a certain quantity of oil of the nature of ſweet oils, which are not volatile, nor ſoluble in ſpirit of wine; ſecondly, of water; thirdly, of vegetable acid; and, laſtly, of an attenuated earth; that the oil which is a principle of gums is in ſmall quantity, ſince they are not attackable by oily or ſpirituous ſolvents; and that they are difficultly combuſtible.

Thirdly, that the portion of oil which is combined in gums is in them ſo intimately united with a ſufficient quantity of acid, that it is rendered entirely ſoluble in water.

Fourthly, that as all compounds, the principles of which are nearly in theſe proportions, and in this kind of union, are ſuſceptible of fermentation, all gummy matters are fermentable; they are alſo nutritive. This is confirmed by experience. Some differences, however, exiſt in this reſpect betwixt the ſeveral mucous vegetable matters. Some of them, particularly thoſe called *gums*, are very tranſparent, inſipid, little nutritive, and ſuſceptible of only an imperfect fermentation, which paſſes ſoon to vapidity or mouldineſs: others, namely thoſe which all the farinaceous ſubſtances furniſh, are leſs tranſparent, leſs inſipid, more viſcid, more nutritive, and ſuſceptible of a compleat ſpirituous fermentation, particularly when they are placed in circumſtances favorable to fermentation. *See* BEER.

Although the exiſtence of mucilage in all vegetables and in all their parts is not equally ſenſible, we may nevertheleſs conſider it as univerſally diffuſed through the vegetable kingdom. Plants, or the parts of plants, from which no mucilage is obtainable by ordinary proceſſes, do all impregnate water with an extractive matter; and this extractive matter includes always a certain quantity of mucilaginous ſubſtance, which remains mixed with the ſaline and ſaponaceous matters, and which might even be ſeparated by certain proceſſes, particularly by a proper application of ſpirit of wine.

The uſe of the mucilaginous matter appears to be in the vegetable kingdom exactly the ſame as that of the gelatinous matter in the animal kingdom. Theſe two ſubſtances, which, in many reſpects, reſemble each other, are both of them ſingularly nutritive and reparative.

Accordingly, nature has provided all the plants which have occaſion for it with plenty of it; and has even produced a ſuperabundant quantity of it for the encreaſe and ſupport of each individual. This ſuperabundance of nutritive matter is reſerved with economy in vegetables, as in animals, for the generation and reproduction of individuals of the ſame ſpecies.

The feed and eggs of animals are then nothing elfe than a provifion of gelatinous matter, intended for the production and nutrition of their young. The fame obfervation is applicable to all the feeds and kernels of vegetables, which may be confidered as their eggs; all which contain fo much mucilage, that it may be eafily obtained abundantly from them by infufion or boiling in water.

Some of thefe, fuch as the feeds called emulfive, furnifh eafily by infufion in water a confiderable quantity of the kind of mucilage which we mentioned above was tranfparent, not very nourifhing or vifcid; but they alfo contain a confiderable quantity of fweet oil, which may be obtained by expreffion alone. The others, thofe called *farinaceous grains*, being bruifed and boiled in water, are almoft entirely reduced to a glue, which is nothing elfe than the kind of mucilage which we mentioned as being very nutritive. Thefe grains do not, like the emulfive feeds, contain an expreffible oil; but a confiderable quantity of oil enters into the compofition of the mucilage. Accordingly, thefe two kinds of feeds contain the fame materials, with this difference, that a large portion of fweet oil is difengaged in the emulfive feeds, and is combined in the farinaceous grains.

The kind of grains called *leguminous*, which are very numerous, contain a meal more mucilaginous than thofe properly called farinaceous; but they are likewife provided with a greater or lefs quantity of fapid or even faccharine fubftance, which alfo is a kind of mucilage, and of a truly nutritive nature. *See* SUGAR.

The roots of many plants are filled with much mucilage or faccharine matter. Some of them are farinaceous; efpecially thofe which produce the entire plant.

Mucilage is eafily obtained from the vegetable fubftances above-mentioned, by infufing or flightly boiling in water thofe which contain it moft abundantly, as linfeed, the feeds of pfyllium, of quinces, the roots of marfhmallows, &c. The water by this means foon becomes ropey and vifcous, like the whites of eggs. The water and heat neceffary for this extraction are incapable of caufing any alteration upon the mucilages, which are therefore obtained exactly in the fame ftate as in the vegetable itfelf.

From many trees much mucilage iffues fpontaneoufly, which being dried by the air and fun, forms gums. Thefe trees are chiefly the acacia, the almond, the peach, the apricot, the plumb, and even the pear and apple-trees. May not this exfudation of nutritive fubftance, which might be confidered as the effect of a fuperabundant quantity of nutritive juice, rather proceed from a ftoppage or too great fulnefs of the veffels containing it? That this exfudation proceeds from a difeafe in the tree, is rendered probable by this remark, that all the trees from which much gum iffues, become languid and dry, and do at length perifh, with all the appearances of trees which die from want of nourifhment.

Gummy and mucilaginous matters ferve for many different purpofes. Gums are employed in the arts, in dyeing, in painting with water-colors, and for giving luftre and firmnefs to ftuffs.

Mucilages are the moft relaxing, emollient, and foftening remedies in medicine. But if we take the term *mucilaginous matter* in its moft extenfive meaning, and apply it, as we may with propriety, to all the farinaceous and faccharine vegetable fubftances, then the above-mentioned advantages are nothing

in comparifon of their infinite utility to us, fince that fubftance conftitutes the chief and fole matter of our nourifhment, whether we obtain it directly from the grains and roots of vegetables which we eat, or that it has previoufly ferved as food to the animals which we ufe as food.

CCCCLXIII. M U F F L E. *See* Vessels (Chemical).

CCCCLXIV. M U S K. *(f)*

CCCCLXV. M U S T. By *muft* is meant the faccharine juice of feveral fruits fufceptible of the fpirituous fermentation, and particularly of grapes, before the commencement of this fermentation. Accordingly, muft is, properly fpeaking, what is commonly called *fweet wine*. *See* Juices (Saccharine) *and* Wine.

CCCCLXVI. M Y R R H. *(g)*

(f) Musk is an animal juice, the moft odoriferous of all known fubftances. Its fmell is very diffufive, and adheres very tenacioufly to fubftances perfumed with it. From thirty grains, water extracted twelve grains, and from the fame quantity, fpirit of wine extracted ten grains. Spirit of nitre and oil of vitriol totally diffolve it. The former deftroys the whole of its fmell, and the latter the greateft part of it. Spirit of falt, dilute fpirit of vitriol, and vinegar, have no effect upon it. Spirit of fal ammoniac diffolves a little of it. Oil of tartar fcarcely acquires any tinge from mufk, but extricates from it a volatile urinous fmell. Mufk is not foluble in oils expreffed or diftilled. By diftillation in a retort, musk yielded the animal principles, empyreumatic oil, volatile fpirit and falt. Musk is ufed medicinally, and as a perfume. In the diftillation of odoriferous waters and fpirit, a fmall portion of musk included in a linen cloth, is generally hung in a ftill-head, the vapors of both liquors extracting its fcent Spirit diftilled with musk immerfed in it acquires little of its fmell. But water by this method acquires both the fmell and tafte. A minute portion of musk greatly improves the fragrance of the diftilled odoriferous waters, as thofe of lavender and rofemary, and heightens the fmell of other odoriferous ingredients, without communicating any of its own peculiar fmell. *Neuman.*

(g) Myrrh is a gum refin, from fixteen ounces of which twelve ounces and a half were extracted by water, and from the fame quantity five ounces were extracted by fpirit of wine. The whole fmell and tafte of the myrrh is received either by the water, or by the fpirit, and the refiduous fubftances are perfectly infipid. By evaporating the aqueous infufion, an extract is obtained, containing all the bitternefs, but not the flavor of the myrrh, which feems to refide in an effential oil; three drams of which may be obtained by diftillation of a pound of myrrh. If fome powdered myrrh be inclofed in the white of a hard boiled egg, and fet in a moift cellar, the liquor into which the egg will be gradually refolved, will extract nearly all the fmell and tafte of the myrrh. This liquor, which is commonly called, *oil of myrrh per deliquium*, may be precipitated and coagulated by fpirit of wine. This coagulum is foluble by water.

N.

CCCCLXVII. NAPHTHA. This name is given to the petroleum which is the moſt white, volatile, and thin, whether this bituminous matter poſſeſs theſe qualities naturally, or has acquired them by rectification. *See* PETROLEUM *and* BITUMENS. *(h)*

CCCCLXVIII. NATRUM *or* NATRON. This is a native alkaline ſalt of the nature of the mineral or marine alkali, which is found cryſtallized in Egypt, and in ſome other hot countries, in ſands which ſurround lakes of ſalt water. This cryſtallization is produced by the ſpontaneous evaporation of this water; and as that water contains other ſalts alſo, beſides the mineral alkali, the natrum is not a pure mineral alkali, and is naturally found mixed with other ſaline matters, and particularly with common ſalt. This ſalt is ſaid to be the nitre of the ancients. It is little known in this country. The ſoda, and ſalt obtained from it, being of the ſame nature as the natrum, ſupply all our purpoſes. *See* ALKALI (MINERAL).

CCCCLXIX. NEPHRITIC STONE. *(i)*

CCCCLXX. NEPHRITIC WOOD. *(k)*

(h) Mr. Rouelle thinks that naphtha is formed by a diſtillation of bitumens occaſioned by ſubterranean fires.

(i) NEPHRITIC STONE. This is a green, ſemi-tranſparent, foliated ſtone, unctuous to the touch, not compact, nor capable of being poliſhed. By Wallerius it is ranked amongſt gypſums; and by Pott, amongſt calcareous earths. Some other authors more juſtly conſider it as a ſteatites, from its unctuoſity, from its partial ſolubility in acids, and from its property of becoming hard by burning. Its green color is occaſioned by copper, a ſmall quantity of which metal Mr. Pott extracted from this ſtone, by fuſion with borax. Neuman affirms, that by diſtilling the ſtone, he obtained a ſmall portion of an empyreumatic oil, and of an ammoniacal ſalt.

(k) NEPHRITIC WOOD. This wood gives a blue color to ſpirit of wine, or to water. This color is changed to a yellow by acids, and afterwards reſtored to a blue by alkalis. Dr. Lewis obſerves, that it is the only woody matter which gives a blue tincture; and that this is the only vegetable blue which is thus deſtructible by acids.

CCCCLXXI. NICKEL. *(l)*

CCCCLXXII. NITRE, *or* SALTPETRE. Nitre is a neutral ſalt compoſed of a peculiar acid, called *nitrous acid*, ſaturated with fixed vegetable alkali.

This ſalt has a ſaline and cooling taſte, which is ſucceeded by another more diſagreeable taſte. It is eaſily ſoluble in water, but in much greater quantity in boiling than in cold water. It is conſequently one of thoſe ſalts which are more readily cryſtallized by cold than by evaporation. Therefore, if fine cryſtals of nitre are required, this ſalt muſt be diſſolved in water, and heat muſt be applied, that the water may take up more ſalt than it can retain when it is cold. When this ſolution of nitre is allowed to cool, many cryſtals will be formed which will be ſo much larger and finer, as the quantity of ſalt operated upon at the ſame time has been greater, and as the cooling of the liquor has been ſlower.

Cryſtals of nitre are oblong ſolids, the large faces of which are parallel. They are kinds of priſms furrowed by parallel and longitudinal grooves.

The acid and alkali, of which nitre conſiſts, are united together ſo intimately, that it may be conſidered as a perfect neutral ſalt. It is not deliqueſcent, but it retains ſtrongly the water of its cryſtallization, by which its tranſparency is preſerved even in a dry air, and it does not effloreſce, or become mealy.

Nitre is one of the moſt fuſible ſalts. It is liquefied by a heat much leſs than what is neceſſary to make it red, and remains thus in tranquil fuſion without ſwelling. If nitre thus melted be left to cool and fix, whether it has been made red-hot or not in this fuſion, it coagulates into a ſolid, ſonorous, ſemi-tranſparent maſs, and is then called *mineral cryſtal*. This melted nitre, or mineral cryſtal, has, excepting the arrangement of the cryſtallization, all the ſame properties as cryſtallized nitre. Mr. Beaumé obſerves, that nitre loſes by fuſion little, if any, of the water of its cryſtallization, ſince the weight of the mineral cryſtal is nearly the ſame as the weight of the nitre employed.

(l) NICKEL is a ſemi-metal, firſt deſcribed by Mr. Cronſtedt, in the Swediſh Memoirs for the years 1751 and 1754. The properties there attributed to it are, 1. That it is of a white color, inclining to red. 2. Its texture is ſolid, and ſhining in its fractures. 3. Its ſpecific gravity is to that of water as 8500 to 1000. 4. It is conſiderably fixed in the fire. 5. It is calcinable, and its calx is green. 6. This calx is not very fuſible, but it nevertheleſs tinges glaſs of a tranſparent reddiſh brown, or jacinth color. 7. It diſſolves in aqua fortis, aqua regia, and marine acid, but difficultly in vitriolic acid. All theſe ſolutions have a deep-green color. The vitriol formed of it is alſo of the ſame color; and the colcothar of this vitriol, and alſo the precipitates from the ſolutions, are rendered by calcination of a light green color. 8. Theſe precipitates are ſoluble by ſpirit of ſal ammoniac, and the ſolution has a blue color. But no copper can be produced by a reduction of the precipitates. 9. It ſtrongly attracts ſulphur. 10. It unites with all metallic ſubſtances, excepting ſilver, quickſilver, and zinc. Its attraction to regulus of cobalt is the ſtrongeſt, next to which is that to iron, and then to arſenic. 11. It retains its phlogiſton a long time in the fire, and its calx is reducible by a very ſmall quantity of inflammable matter. It requires, however, a ſtrong red heat before it can be fuſed, and melts a little ſooner, or as ſoon as, gold or copper. Nickel is contained in the reddiſh-yellow mineral, called *Kupfer-nickel*, which, beſides nickel, contains alſo iron, regulus of cobalt, arſenic, and ſulphur.

Hence the liquefaction of the nitre, even at first, ought not to be attributed to the water of its crystallization, as is the case with Glauber's salt and many other salts, but is a true fusion from the beginning; and this fusibility of nitre is caused by the water which enters into its composition as a salt, and not merely as a crystallized salt. Accordingly, mineral crystal is as fusible as nitre itself. The fusibility of nitre may also probably depend considerably on the inflammable principle which enters its composition, and particularly the composition of its acid. *See* ACID (NITROUS).

When nitre is kept in fusion with a moderate heat, while at the same time it does not touch any inflammable matter, nor even flame, it remains in that state without suffering any very sensible alteration. But if it be kept in a strong fire, it becomes more and more alkalised, because then the flame or burnt phlogiston penetrates it, even through the crucible, sufficiently to destroy the acid of the salt. *See* ACID (NITROUS), *and* DETONATION *of* NITRE.

From this property of being alkalised by a strong heat alone, it assists the fusion and vitrification of flints and sands as pure alkalis do. A considerable part, nevertheless, of the nitrous acid may possibly remain in the vitrified substances, or may even contribute to the fusion. *See* VITRIFICATION.

All these substances, which contain phlogiston fixed in a certain degree, and which are nevertheless combustible, being made red-hot and applied to nitre, accelerate greatly the alkalisation of this salt, and render it compleat, if these substances be in sufficient quantity; and reciprocally, nitre accelerates much and compleats the calcination or combustion of these substances, because its acid assists the burning of their phlogiston, and burns itself along with this inflammable principle.

This alkalisation is made with or without any sensible detonation, according to the state, the quantity, and the greater or less intimacy of the mixture of the inflammable matters. And the nitre thus decomposed or alkalised is frequently called *nitre fixed* by such or such substance; for instance, *nitre fixed by tartar*; *nitre fixed by coals*, when it is alkalised by tartar or by coals. This name of *fixed nitre* is improper: for when the operation is finished, the residuum contains nothing nitrous, but only the alkali of nitre, with the ashes or earth of the inflammable matter employed for this alkalisation.

The phenomena which nitre exhibits, when it is decomposed by means of phlogiston, are numerous and interesting The detail and explanation of them may be found under the article DETONATION *of* NITRE.

Nitre is capable of being decomposed by several other substances. These are, pure vitriolic acid; vitriolic acid engaged with an earthy or metallic base; sedative salt; arsenic; and phosphoric acid. But none of these substances acts upon nitre in the same manner as phlogiston does. They do not, like phlogiston, destroy its acid, but only disengage and separate it from its alkali. Hence it follows, 1. That after the decomposition of nitre, by means of these saline substances, its alkali does not remain alone, but a combination of this alkali with the substance employed for the decomposition. 2. If we make the operation in vessels proper for distillation, the nitrous acid which has been separated during the operation from its alkali may be obtained. For the detail of these operations see the words, SPIRIT *of* NITRE, SALT (NEUTRAL ARSENICAL), SALT (SEDATIVE), *and* PHOSPHORUS.

Nature furniſhes us with a very ſmall quantity of nitre ready formed, in comparifon of the quantities which are employed. Nitre is found naturally cryſtalliſed in India, and as it is ſwept from earths or ſtones with brooms, it is called the *ſweepings of nitre* or *of ſaltpetre*. A nitre may be obtained from ſeveral plants. Theſe are the two kinds of natural nitre. All other nitre is only begun by nature, and is found in the walls of old buildings. Art is required to compleat it, to extract it, and to purify it, as we ſhall proceed to explain, after having made ſome reflexions on the generation of this ſalt.

As neither nitre nor nitrous acid, engaged in any baſe whatever, is any where found collected from time immemorial in great quantities, as the vitriolic and marine acids are, but is only found produced from time to time in places where not an atom of this ſalt exiſted; it evidently appears to be habitually produced by the concurrence of circumſtances favorable to its formation.

Some chemiſts and naturaliſts believe, that becauſe nitre is commonly obtained from ſubſtances long expoſed to air, that nitrous acid exiſted ready formed, like the other two mineral acids, and that it is ſucceſſively depoſited in matters proper for its reception. But this opinion is quite rejected, particularly by chemiſts, ſince they have been aſſured from experience, that by a long expoſure of the moſt proper ſubſtances for the reception and retention of nitrous acid, as fixed alkali, to the air, no nitre is ever obtained. Cloths ſoaked in fixed alkali, and expoſed to air by hanging freely, are indeed at length filled with cryſtals of a neutral ſalt; but this is vitriolated tartar, and not nitre.

On the other ſide, we are certain that nitre or nitrous acid, engaged in any baſe, is never found but in places capable of being impregnated with vegetable or animal juices. Hence, it is never found in any place inacceſſible to theſe matters, as in very great heights or deeps.

Mr. Lemery the younger conſidering theſe things, and that nitrous ſalts or perfect nitre are obtained by analyſing many vegetable and animal matters, has concluded from thence, that this ſalt exiſts naturally ready formed in the individuals of theſe two kingdoms, which are, according to him, the only ſource of it. In the Memoirs he has given upon this ſubject, he explains how nitre, or rather nitrous acid, which is either at firſt not perceptible, or in ſmall quantity, in animals and vegetables, may be afterwards unfolded by the action of the air, and by the fermentation excited in theſe compound bodies as ſoon as their life ceaſes.

But this opinion, although ſpecious, is liable to great difficulties; for vegetables and animals are not permanent beings, but are continually produced and deſtroyed. The peculiar ſubſtances then, of which they are compoſed, conſiſt of principles extracted from the air and the earth. We may therefore object to Mr. Lemery, that the nitre found in animals and vegetables is extraneous to them, and proceeds originally from the air and the earth.

This objection is ſupported by a well-known fact, namely, that the moſt nitrous plants contain very unequal quantities of it, according to the quantity of the nitre which is contained in the ſoil or earth in which they grow. Beſides, vegetable and animal ſubſtances may be putrified without affording a larger quantity of nitre, unleſs it has been expoſed to the air and mixed with earthy and ſtoney matters. Vegetable and animal matters contain the nitre or nitrous acid ready formed, only *accidentally*; they do not even always contain

tain all the materials neceſſary for its production: and all that we can infer is, that the concurrence of animal and vegetable matters is neceſſary for this production of nitre.

The third opinion concerning the origin of nitre is that of Stahl. This chemiſt, who thought, with Beccher, that the vitriolic is the only original acid, and that from this all other acids are produced, believed that the nitrous acid is only the vitriolic acid metamorphoſed by the union it contracts with ſome other principle. This principle, according to him, is phlogiſton: and putrefaction is the method employed by nature to combine this acid with the inflammable matter of putrifying ſubſtances, in the convenient proportion and manner for giving to it the ſpecific character of nitrous acid.

This is the moſt probable opinion of all. For without conſidering the analogies which are obſervable betwixt the nitrous and the volatile ſulphureous acids, moſt of the circumſtances attending the origin of nitre ſeem to be further proofs of it.

Firſt, the atmoſphere appears to contain the vitriolic acid, or ſome matter in which it exiſts, and from which it is depoſited in proper baſes.

Secondly, nitre is never found but in earths or ſtones which have been impregnated with vegetable or animal juices, and theſe juices muſt have remained a ſufficiently long time to have ſuſtained the whole putrefactive proceſs.

Thirdly, Meſſrs. Mariote and Lemery have expoſed to pure air, during a long time, earths and ſtones very fertile in nitre, after having deprived them of all their contents, and no nitre was formed in them, becauſe they had not again imbibed any vegetable or animal juices.

Laſtly, the Academy of Sciences at Berlin, having propoſed ſome years ago, for the ſubject of their annual prize, to determine the origin and principles of nitre, Dr. Pietchs, who obtained the prize, ſays in his Diſſertation, that having ſoaked with urine and vitriolic acid a calcareous ſtone, and having afterwards expoſed it to the air during ſome time, he found it afterwards full of nitre. This experiment is favorable to Stahl's opinion, which Mr. Pietchs adopts in his Memoir.

One part indeed of the obſervations which we have related agrees alſo with Mr. Lemery's opinion. But whether nitre be produced in vegetables and animals during their life, as Lemery believes; or whether a part of the principles of theſe ſubſtances combines afterwards with the vitriolic acid diffuſed in the air, or pre-exiſting in earths and ſtones, as Stahl ſays; this may certainly be inferred, that nitre does not exiſt ready formed, and in great quantities in nature, as the vitriolic and marine acids are, but that it is generated and produced from time to time by the concurrence of circumſtances favorable to its formation.

We may obſerve upon the ſubject of the principles and production of the nitrous acid, that as we have ſhewn that putrefactive matters are requiſite to its formation, and as vegetable and animal ſubſtances are only ſuſceptible of putrefaction, this acid therefore belongs equally to the three kingdoms of nature.

Nitrous acid is not commonly found diſengaged: neither is it generally united with any one particular baſis, as marine acid is; but it is no ſooner generated, than it combines with any matters which it can diſſolve, and which are within

its

its reach. Accordingly, it is sometimes united with a fixed alkali, and consequently forms ordinary nitre; such are what are called the sweepings of nitre and the nitre of plants; but most frequently it is combined with absorbent earths, because it generally meets these in places where it is formed most copiously: it is, therefore, most generally found in the form of nitre with an earthy basis.

The most favorable places for the production of nitre are the habitations of men and animals, and particularly such as are low and moist, as cellars, kitchens, stables, houses of office, and others of that kind, which are apt to to be impregnated with vegetable and animal matters, and also to have an habitual moisture, which is favorable to putrefaction; and, lastly, which are sheltered from rain, which might otherwise dissolve and carry off the nitre as soon as it is formed.

These buildings are true nitre-beds. When they are old, their rubbish and plaster are full of nitre: but this nitre is only a nitre with an earthy basis, which is not susceptible of crystallization or detonation, which are the two essential qualities in nitre for the principal uses to which it is applicable, and which it cannot possess but by being joined to a basis of fixed alkali. Besides, the nitre of rubbish is mixed with much common salt, which comes also from the vegetable and animal matters, and from some heterogeneous substances, which alter its purity. The chief intention, therefore, of the operation upon rubbish, to obtain a perfect nitre, is to furnish this salt with a basis of fixed alkali, and to disengage it from the heterogeneous matters which alter its purity. These views are accomplished in the following manner.

The rubbish containing nitre is to be broken to small pieces, and mixed with nearly an equal quantity of wood-ashes. This mixture is to be put into casks ranged along each other, placed vertically on one of their ends, and supported at the height of two feet above the ground. At the bottom of each cask is a hole, filled with straw. Water is to be poured into the first cask; and this water, when impregnated with all the saline matter in the mixture, flows into a bucket placed under the cask for its reception. This same water is poured successively into the other casks, and thus becomes impregnated with more and more saline matter. The makers of salt-petre observe always to pass the strongest lixiviums through casks filled with new matter; and before they throw away the matter of a cask when almost exhausted, they pass through it the first water yet unimpregnated. By these operations, which are well contrived, they obtain a lixivium as much impregnated as it can be, and they at length entirely exhaust the rubbish of all the nitre it contained.

The lixivium of nitre thus prepared is carried to great copper cauldrons, in which it is boiled and evaporated, till it is sufficiently strong for the crystallization of the salts. As the two crystallizable salts contained in this lixivium are nitre and common salt, and as the latter of these salts is crystallizable by evaporation only, and the second by cold only; the common salt crystallizes first during the evaporation, and forms small cubical crystals which subside to the bottom of the cauldron. The salt-petre-makers call it the *grain*. They take it out with large ladles, and put it in a basket hung over the cauldron to drain. This evaporation is continued, and the grain is to be taken away as fast as it is formed, till the liquor be so much evaporated, that, when it is cold, much nitre will

will be cryſtallized in it; and in order to diſcover when it is ſufficiently evaporated for that purpoſe, a ſmall quantity of it is to be taken out from time to time. When they perceive, upon cooling the liquor, that a ſufficient quantity of nitre is formed in it, they remove the liquor from the cauldron into large copper baſons, which they carry to a place deſigned for the cryſtallization.

As this liquor contains much nitre, and as it is quickly cooled, the greateſt part of the ſalt is coagulated at the bottom of the baſons in unſhapely maſſes, compoſed of many ſmall needle-like cryſtals of nitre, and ſometimes of large regular cryſtals upon their ſurfaces. Theſe are called *ſticks of nitre*.

In the baſons remains a large quantity of liquor, the nitre contained in which cannot be cryſtallized but by a ſecond evaporation, which is therefore performed in the ſame manner as at firſt, and more nitre is obtained. This operation is repeated till no more nitre can be formed by cooling the evaporated liquor, which then becomes very red and acrid, and is called the *mother-water of nitre*.

This mother-water is compoſed almoſt entirely of nitre and common ſalt with earthy baſes, which certainly proceed from too ſmall a quantity of aſhes having been mixed with the lixivium of the nitrous rubbiſh. This mother-water may therefore be avoided, by mixing a ſufficient quantity of aſhes with the nitrous rubbiſh, to decompoſe all the ſalts with earthy baſes which it contains; and thus, after the ſeveral evaporations and cryſtallizations, nothing would remain but a ſmall quantity of red liquor impregnated with unctuous matter.

When only the uſual quantity of aſhes is employed, the baſis of the earthy ſalts contained in the mother of nitre may be precipitated by adding an alkaline lixivium. This precipitate is white, and is called the *magneſia of nitre*; and, at the ſame time, the nitre with earthy baſis in the mother-water, being changed into a nitre with baſis of fixed alkali, is eaſily obtainable by cryſtallization: but the ſalt-petre-makers do not employ any of theſe methods with their mother-water, which they throw upon the nitrous rubbiſh after it has been exhauſted of its ſalt by lixiviation. Some time afterwards, they lixiviate this rubbiſh in the ſame manner as they did at firſt, that is, with the addition of aſhes, and obtain from it more nitre. We may eaſily perceive that this operation is preciſely upon the ſame principles as one of thoſe we have propoſed. *See the words* WATER (MOTHER), NITRE *with* EARTHY BASIS, SALT (COMMON) *with* EARTHY BASIS.

The nitre obtained by theſe cryſtallizations is red, and ſoiled by the liquor in which it was diſſolved, which has alſo that color. Further, although common ſalt does not cryſtallize by cold alone, yet a certain quantity of it always cryſtallizes along with the nitre; both becauſe the evaporation continues while the liquor cools, and becauſe the nitre, during its cryſtallization, always takes with it a portion of common ſalt.

This nitre, which the manufacturers call *nitre of the firſt boiling*, is therefore impure, and mixed with common ſalt, and with ſalts with earthy baſes, by which it is rendered unfit for many of the uſes to which nitre is applied, as we ſhall afterwards ſee. It is purified by diſſolving it in pure water, and by proceeding to a ſecond cryſtallization by cold; and as in this ſecond cryſtallization, the proportion of nitre to common ſalt, and to ſalts with earthy baſes, is infinitely greater than at firſt, ſo that when the liquor is at the point of the cryſtallization of the nitre, it is very far from being ſo much evaporated that the common

mon ſalt can cryſtallize at that time; and therefore the nitre obtained in this ſecond operation is infinitely purer than that of the former. It is alſo white, and is called by the manufacturers *nitre of the ſecond boiling*. This is the nitre employed by diſtillers of aqua-fortis, for the ordinary aqua-fortis.

But this nitre is not yet ſufficiently pure for the preparation of good gunpowder; and it muſt therefore be purified by a third boiling or cryſtallization. This is the pureſt nitre that is ſold, or that is kept in arſenals. It is very beautiful and white: but it is not yet ſufficiently pure for certain delicate operations in chemiſtry, and muſt therefore undergo a fourth purification. For the underſtanding of the theory of the operations for the extraction and purification of nitre, *ſee the article* CRYSTALLIZATION *of* SALTS.

All nitrous earths and ſtones which are found, contain alſo a conſiderable quantity of common ſalt. The late Mr. Petit, who has given, in the Memoirs of the Academy of Sciences, a good deſcription of the manufactory of ſalt-petre, ſays, that the quantity of common ſalt contained in the materials is nearly a fourth part of the quantity of nitre. It is even probably more, if we comprehend the common ſalt with earthy baſis contained in the mother water of nitre.

This common ſalt is depoſited in the nitrous earths and ſtones by the vegetable and animal juices which are neceſſary to the generation of nitre, all which contain more or leſs common ſalt. The exiſtence of this common ſalt in all nitrous ſubſtances has induced ſome chemiſts to believe that the marine acid was converted into the nitrous. I have heard that a certain perſon had the ſecret of transforming common ſalt into nitre, and that he had propoſed to furniſh nitre at a cheap rate. A more particular examination of this matter deſerves to be made by chemiſts.

No uſe is made in France of the common ſalt in the manufacturing of ſalt-petre. The farmers-general oblige the manufacturers to give an exact account of it, and to throw it into the river. The purification of it would be difficult; becauſe, during the making of the ſalt-petre, a febrifugal ſalt of Sylvius is formed, by the union of the vegetable alkali of the aſhes, with the acid of the marine ſalt with earthy baſis; and becauſe the ſalt of Sylvius has all the properties of common ſalt, only that its taſte is very diſagreeable.

The uſe of nitre is very extenſive in medicine, and in the arts, and in chemiſtry. Perſons who know little of chemiſtry muſt be ſurprized that this ſalt, ſo inflammable, ſhould be employed in medicine as a powerful diuretic, ſedative, and cooler; which virtues it certainly poſſeſſes. It is daily preſcribed by the moſt ſkillful phyſicians, from ten or twelve grains to half a dram, in ſome proper drink. It might be given without danger in a much more conſiderable quantity; for this ſalt, which is perfectly neutral, is very mild; but it has been obſerved to produce its intended effects better when it is given in the above-mentioned quantity only. (*m*)

(*m*) Some curious experiments concerning the effects of nitre taken internally are related in *Mr. Alexander's Experimental Eſſays*. From theſe it appears, that nitre has a power of almoſt inſtantly retarding the velocity of the circulation of the blood, and of ſurpriſingly diminiſhing the number of arterial pulſations; and that its effects are much more powerful, when newly diſſolved in water, than when it had remained diſſolved during ſome hours. As this difference muſt have proceeded from the cold, which is produced

Besides the nitrous acid obtained from nitre, which is one of the most powerful agents in chemistry, nitre itself is also used in many chemical operations. Its properties of detonating with bodies containing phlogiston, of accelerating their calcination, and particularly the calcination of the imperfect metals, render it useful for the purification of gold and silver when they are allayed with other metals. As nitre is quickly and easily alkalised, it enters into the composition of reducing fluxes, or of simple fluxes, to assist fusion and vitrification. Lastly, by its detonation it may be employed to discover the presence of the inflammable principle in substances.

But the most considerable use and consumption of nitre is in the preparation of gun-powder, of which this salt makes a great part; and for this purpose it must be very pure *See* POWDER (GUN), *and* POWDER (FULMINATING).

CCCCLXXIII. NITRE (ALKALISED.) This is the fixed alkali which remains after the nitrous acid has been destroyed by its detonation with any inflammable matter. This alkali is generally called *fixed nitre*. *See* NITRE (FIXED).

CCCCLXXIV. NITRE (AMMONIACAL). This is a neutral salt resulting from the combination of the nitrous acid, to the point of saturation, with volatile alkali. *See* AMMONIACAL (NITROUS) SALT.

CCCCLXXV. NITRE (CALCAREOUS), or NITRE *with* EARTHY BASIS. Calcareous nitre is a neutral salt compounded of the nitrous acid combined to saturation with a calcareous earth. It is generally called *nitre with an earthy basis*, because the salts formed by the nitrous acid with the other earths have not been attended to.

Nitrous acid dissolves with great activity all calcareous earths and stones, calcined or uncalcined. It dissolves a large quantity of them, and leaves no residuum when they are pure. By this combination is formed a neutral salt very deliquescent. This salt is not susceptible of a true crystallization. It has a poignant, acrid, and bitter taste. If it be evaporated to dryness, it becomes solid, and seems to be an earthy matter, which does not detonate, or at least very weakly, with inflammable matters.

All these properties of nitre with an earthy basis proceed from the weak adhesion of its acid to the earth. This adhesion is so weak, that if the salt be distilled in a retort, an acidulous phlegm will first pass over; and when the fire is encreased, all the acid will follow, excepting a small portion which adheres more strongly, but which may be at last expelled by calcination in an open fire.

Mr. Pott, who has particularly examined the combination of nitrous acid with quicklime, says, that this acid suffered remarkable alterations by distillation from quicklime, and by repeated cohobations. By these experiments he obtained a nitrous salt more sensibly susceptible of crystallization and detonation than ordinary nitre with earthy basis; which is very remarkable, and may induce us to suspect that a part of the nitrous acid, and of its inflammable principle, might combine with the quicklime, so as to give it the character of

duced by nitre during its solution, probably a much greater effect would be produced by procuring that solution in the stomach. A remarkable instance is given in that book of a sudden swelling over the whole body of a woman, and other dangerous symptoms, which were occasioned by her swallowing a solution of nitre in water, by mistake, instead of Glauber's salt.

a fixed

a fixed alkali; or that the nitrous acid, deprived by the quicklime of part of its phlogiston, might be rendered more capable of contracting a strong union with the quicklime. From what Mr. Pott has said in his Dissertation, the nitrous acid seems, by treatment with quicklime, to be rendered susceptible of an entire decomposition. *See his Dissertation in the French edition of his works, by Mr.* MACHY, *tom.* III. *p.* 178.

A great quantity of nitre with earthy basis is found ready formed in nitrous earths and stones. Nitre is most frequently produced in that form. This nitre may be decomposed by a fixed alkali, which unites with its acid, and precipitates the earth, in the process for making salt-petre. The mother-waters obtained in these operations contain still a large quantity of this nitre with earthy basis. *See the word* NITRE *in the preceding article.*

CCCCLXXVI. NITRE (CUBIC *or* QUADRANGULAR). When nitrous acid is saturated with mineral alkali, a neutral salt is formed, susceptible of crystallization and of detonation, and consequently is a kind of nitre. This salt has all the essential properties of nitre with basis of fixed vegetable alkali; but the marine alkali, which is its basis, changes the form of its crystals, which are not channelled prisms, like those of ordinary nitre, but are cubes, or sometimes parallelipipedons, with rhomboidal faces. From these forms the salt has been called *quadrangular nitre.*

We may make quadrangular nitre by combining directly the nitrous acid to the point of saturation with the crystals of soda, or by precipitating with this alkali the solutions of earths and metals made by nitrous acid, or by precipitating with common salt the metallic solutions in nitrous acid, which are susceptible of this precipitation; or, lastly, by decomposing common salt by pure nitrous acid in the operation for making the distilled aqua regia. In all these cases the nitrous acid is evidently combined with marine alkali, and forms cubic nitre. This salt is not used in medicine, chemistry, or the arts, as it is rather inferior than preferable to ordinary nitre.

CCCCLXXVII. NITRE FIXED *by* ARSENIC. This preparation is the alkali of nitre, the acid of which has been expelled in an open fire by means of arsenic, of which, therefore, some portion is retained by the alkali. To make this preparation, some nitre is to be put into a crucible, which is to be placed in a furnace. When the nitre is red, a small spoonfull of white arsenic powdered is to be projected upon it, which causes a great effervescence, and afterwards vapors to ascend; so that these phenomena are similar to those which happen when nitre is detonated. They are, however, different. In the detonation of nitre, the acid is burnt and destroyed; but in this operation the acid is only disengaged from its basis by means of the arsenic which has that property. The ebullition above-mentioned is caused by the powerful action of arsenic upon nitre. The fumes which rise copiously in this operation are a mixture of those of very concentrated nitrous acid with a part of the arsenic which is sublimed by the heat.

Arsenic is thus projected at different times into the crucible, till no more effervescence is perceived, and then the operation is finished. The fumes which rise in this experiment must be very noxious, and therefore it ought always to be done under a chimney which draws well.

As arsenic cannot disengage the nitrous acid but in proportion as it combines with the basis of the nitre, we might expect to find in the crucible, after the operation, the alkali of the nitre perfectly saturated with arsenic. Nevertheless, the remaining matter is very alkaline, very far from the point of saturation, and retains but a little arsenic. The cause of this is, that the contact of the air and the vapor of the coals make most of the arsenic fly off as fast as it combines with the alkali; for when the evaporation is made in close vessels, the alkali of the nitre is neutralised, and entirely saturated with arsenic. *See* ARSENIC, *and* SALT (NEUTRAL ARSENICAL).

Nitre fixed by arsenic cannot be employed but as an alkali which contains a certain quantity of arsenic, and mixed with a small portion of nitre which may escape the action of the arsenic towards the end of the operation. This alkali may be employed as a flux, as it powerfully assists vitrification, as Mr. Pott has done in his experiments mentioned in the Lithogeognosia.

CCCCLXXVIII. NITRE FIXED *by* COALS. To make nitre fixed or alkalised by coals, the proper quantity of nitre is to be put into a crucible, which ought to be so large that the nitre shall take up but a small space in it. This crucible is to be placed in a well kindled fire; and when the nitre is melted and red-hot, a small spoonfull (about a dram or half a dram) of charcoal grosly powdered is to be projected upon it. Instantly a vivid inflammation happens, which continues till all the charcoal is entirely consumed. When this inflammation or detonation ceases, another quantity of charcoal like the former is projected upon it, and is left to be consumed; and thus charcoal is continually to be projected till no more detonation is caused by it.

Then the matter contained in the crucible, which at first is very fluid, becomes afterwards thick and almost solid, because it is then fixed alkali, which is much less fusible than nitre. The fire must be encreased sufficiently to make this alkali melt. During this fusion, some small detonations happen from time to time, which are occasioned by a portion of nitre which the large quantity of alkali, and the want of fluidity towards the end of the operation, had preserved from the contact of the coals. When the matter is in good fusion, and no detonation happens upon projecting small bits of coals, we may then know that the nitre is alkalised, and that the operation is finished. We ought to remark upon this subject, that when the smallest possible quantity of nitre undecomposed is intended to be contained, more coal must be added than seems to be necessary for alkalising the quantity of nitre. In this case the alkali is generally phlogisticated, unless it be afterwards calcined a very long time in an open fire.

If, on the contrary, it is intended to be as much dephlogisticated as possible, and incapable of giving or retaining any extraneous taste or smell; and if its perfect purity from undecomposed nitre be not required; then in the preparation less charcoal ought to be used than is necessary for the detonation of the whole quantity of nitre. This remark is also applicable to nitre alkalised by tartar and by all other inflammable matters. *See* ALKALI (FIXED VEGETABLE), *and* DETONATION *of* NITRE.

CCCCLXXIX. NITRE FIXED *by* METALS. All the metallic ſubſtances which are ſuſceptible of decompoſition being treated in the fire with nitre, alkaliſe it, and make it detonate more or leſs ſenſibly. The moſt inflammable of theſe ſubſtances, as zinc and iron, make with this ſalt ſo luminous and ſo brilliant a detonation, that they are advantageouſly employed for that purpoſe in fire-works. Other combuſtible matters are leſs effectual, but their inflammation with nitre is ſufficiently ſtrong to produce all the eſſential effects of the detonation of nitre; ſo that after this inflammation, the acid of the ſalt is deſtroyed and burnt with the phlogiſton of theſe metals, and its alkali only remains mixed with the earth of the calcined metals. We may then ſay, that nitre is fixed by metals, as well as we ſay that it is fixed by coals or by tartar.

After the detonation of nitre with metals, its alkali may be eaſily obtained alone, and ſeparated from the metallic earths, by lixiviating with water the remainder. By filtrating and evaporating this water, this kind of fixed nitre may be obtained in a dry ſtate. It is eſſentially the ſame as nitre alkaliſed by any other inflammable matter, only that it is much more acrid and cauſtic, and reſembles thoſe alkalis which have been treated with quicklime.

In ſome known operations of chemiſtry we may obſerve this cauſticity which the alkali of nitre acquires after detonation with metallic matters. Such are the operations for diaphoretic antimony, and for the tincture of metals, or *lilly of Paracelſus*, in which the alkaliſed nitre is rendered exceedingly cauſtic by the metallic calxes. As, on the other ſide, volatile alkali treated with theſe metallic earths becomes always *fluor*, in the ſame manner as when treated with quicklime, we may conclude that metallic calxes act in general upon alkalis as quicklime does. *See the articles of the ſeveral metals, and of* ALKALI (FIXED), *and* DETONATION *of* NITRE.

CCCCLXXX. NITRE FIXED *by* TARTAR. This alkali is made by mixing together equal parts of nitre and tartar, which ought to be only groſsly powdered. This mixture is to be put into an open veſſel of unvarniſhed earthen-ware, or of iron. It is to be placed under a chimney, and it is to be kindled with a lighted coal. It kindles around the charcoal, and deflagrates at firſt weakly; but as the matter firſt inflamed kindles the reſt, the detonation encreaſes, a thick fume riſes, and the whole mixture is inflamed. The red and burning matter melts, boils, and flows over the veſſel if this be not ſufficiently large: then the detonation gradually diminiſhes, and at laſt ceaſes. The reſiduum conſiſts of the alkalis of nitre and of tartar mixed together.

This alkali, as well as the nitre fixed by coals, are each of them very pure and good. They are, however, ſubject to contain a conſiderable quantity of nitre undecompoſed, and of inflammable matter not burnt, particularly when a ſmall quantity only is prepared at once: but it may be compleatly alkaliſed by a proper calcination, and by treating them like other fixed alkalis. *See* ALKALI (FIXED VEGETABLE).

Nitre fixed by tartar is alſo called *white flux*, becauſe the moſt frequent uſe of this alkali is to facilitate the fuſion of ores and metallic matters in eſſays and

ſimilar operations, for which purpoſes it need not be perfectly pure. *See* FLUX (WHITE), *and* DETONATION *of* NITRE.

CCCCLXXXI. NITRES (METALLIC), *or* NITRES *with* METALLIC BASES. Thus may be named all neutral ſalts compoſed of the nitrous acid united with a metallic ſubſtance; and the ſeveral kinds of theſe nitres may be diſtinguiſhed by ſaying, nitre of ſilver, nitre of lead, of mercury, &c. *See* SALTS.

The nitrous acid acts in general powerfully upon all metallic ſubſtances, but with remarkable differences, depending on the peculiar natures of the metals.

Some metals, as gold and platina, cannot be diſſolved in their ſtate of aggregation by nitrous acid alone, and require the concurrence of marine acid. Others, as tin and regulus of antimony, are attacked ſo powerfully, and are ſo well dephlogiſticated by nitrous acid, that, as ſoon as they are diſſolved, they are reduced into a white calx, which ſeparates from the acid, and cannot remain united, becauſe they want phlogiſton. The marine acid combined with nitrous acid moderates much the action of the latter acid on theſe metals, prevents their calcination, preſerves a part of their phlogiſton, and thus is an intermediate ſubſtance by which they remain united with the nitrous acid.

Other metals, ſuch as copper and iron, are eaſily ſoluble by nitrous acid alone, and remain united when the acid is in much larger quantity than is neceſſary to diſſolve the metal: but when the acid is ſaturated, a part of theſe metals always precipitates in ſtate of calx, and the part which remains united with the acid forms an imperfect neutral ſalt, very deliqueſcent, and not, or very little cryſtallizable.

Laſtly, the other metals, particularly thoſe called *white* or *lunar*, ſuch as ſilver, lead, mercury, biſmuth, and even regulus of arſenic, are very ſoluble in nitrous acid, which they ſaturate, from which they do not precipitate without addition, but form with it compleat neutral ſalts ſuſceptible of cryſtallization.

Nitrous acid adheres ſo ſtrongly to theſe metals, that the metallic ſalts formed by them are ſuſceptible of detonation, but not ſufficiently to reſiſt the action of fire, which expels it without the help of any intermediate ſubſtance.

The nitre of ſilver is known by the name of lunar cryſtals. *See* CRYSTALS (LUNAR). Mercurial nitre is alſo frequently called *cryſtals of mercury*. This ſalt reſembles much the nitre of ſilver by its principal properties. *See* MERCURY. The nitre of lead has this peculiarity, that by expoſure to fire without addition of inflammable matter, it decrepitates ſtrongly, and even inflames and detonates. This phenomenon muſt be attributed to the phlogiſton of the lead which is the baſis of this ſalt. Much danger therefore attends the expoſure of nitre of lead to fire in cloſe veſſels. Probably the nitre of biſmuth, and that of regulus of arſenic, would exhibit the ſame phenomenon, as the phlogiſton of theſe two ſemimetals is as inflammable as that of lead.

CCCCLXXXII. NUTMEG. (*n*)

(*n*) Nutmegs. This fruit contains two kinds of oils, namely, a groſs ſebaceous oil, and a volatile eſſential fluid oil; in which laſt the peculiar taſte and ſmell of nutmegs reſide. The eſſential oil alſo appears to be of two kinds; one of which is ſo light, as to ſwim upon water, and to riſe in diſtillation with ſpirit of wine; and the other is ſo groſs and ponderous, that it ſinks in water, and is with difficulty capable of being diſtilled with water, and not at all with ſpirit of wine. Sixteen ounces of nutmegs yielded, by diſtillation, half an ounce of eſſential oil, and afterwards four or five ounces of the groſs ſebaceous oil were found floating on the ſurface of the water in the ſtill. Rectified ſpirit of wine diſſolves all the eſſential oil, and a part of the expreſſible oil. From four ounces of nutmegs nine drams of a concrete oil were expreſſed. This oil contains a conſiderable portion of the eſſential oil. It is brought from India, in form of cakes, and is called *oil of mace*, the mace being one of the exterior coverings of the nutmeg, and containing ſimilar oils. *Neuman.*

CCCCLXXXIII.

O.

CCCCLXXXIII. OCHRE. (o).
CCCCLXXXIV. OCULUS MUNDI. (p).
CCCCLXXXV. OFFA ALBA. (q).
CCCCLXXXVI. OIL. Oil may in general be defined a compound body, little, if at all, ſoluble in water, which is capable of burning with a flame accompanied with ſmoke and ſoot, and of leaving a reſiduum of coal after its diſtillation.

All oils are compoſed of phlogiſton, acid, water, and earth; for all theſe principles are diſcovered in the decompoſition of any oil, as we ſhall ſoon ſee.

(o) OCHRE. Ochres are ferruginous earths, or calxes of various colors, red, yellow, brown. They ſeem to have been depoſited from ferruginous or vitriolic waters, nearly in the ſame manner as a reddiſh or yellowiſh powder is precipitated from ſolutions of iron in vitriolic acid merely by expoſure to air. By reduction with charcoal or other inflammable matter, a conſiderable quantity of iron may be extracted from theſe earths. Wallerius ſays, that the iron thus obtained from ochres is of the kind called *red-ſhort*, that is, brittle when hot. Ochres are uſed as pigments. By calcination, they all acquire a red color. *See* ORES *of* IRON.

(p) OCULUS MUNDI is a variety of the opal. *See* OPAL. It is opake, and its color is generally yellowiſh. It has this peculiar property, that by lying ſome hours in water, it becomes tranſparent, and of a yellow amber color. Some are ſaid to acquire by this means a luminous flame color.

(q) OFFA ALBA, *or* OFFA HELMONTII. When rectified ſpirit of wine is added to a ſolution of mild volatile alkali in water, the ſpirit having a ſtronger diſpoſition than the alkali to unite with the water, and having no diſpoſition to unite with the alkali, precipitates the alkali from the water. The alkali thus precipitated, being mild, or combined with fixable air, acquires a ſolid or concrete ſtate, and is not different from the common mild concrete volatile alkali. It is called the *offa alba*, or *offa Helmontii*. No ſuch precipitation is effected by adding rectified ſpirit of wine to the cauſtic volatile alkaline ſpirit made with quicklime, becauſe the diſpoſition which cauſtic volatile alkali has to unite with water is ſo much ſtronger than that of mild volatile alkali, that the former cannot be ever obtained in a concrete ſtate. *See* ALKALI (VOLATILE).

But perhaps the water and earth which are in oils are in them combined together, and exist in the state of an acid.

From what we have said concerning the nature of oil, this substance appears to consist of several principles (*r*). It is also one of the proximate principles of all vegetables and animals. The oil in these substances even constitutes the essential distinction betwixt them and those of the mineral kingdom, for in no mineral can the smallest particle of oil be shewn. *See* KINGDOMS.

All the oil obtained from vegetable and animal substances has a certain number of general properties which form its character as oil; but is also much diversified by many peculiar properties, according to the particular kinds of vegetable and animal matters from which it is extracted. Hence, the several kinds of oils are distinguishable from each other. In the present article we shall only mention the most general properties of oil.

All oils in general are volatile, that is, they may by a certain heat be raised into vapors. The heat necessary to evaporate the least volatile oils is not even very considerable. It is much less than a red heat; accordingly oil may be considered as a volatile body.

All oils which are exposed to a heat capable of evaporating them, are easily inflammable, in open air, by contact of any inflamed matter, and burn with a white, luminous flame, accompanied with smoke. Oils, like all other combustible bodies, are entirely decomposed by their inflammation. This inflammability of oil shews that phlogiston is one of its principles.

The inflammable property of oil has misled the ancient chemists down to the time of Beecher and Stahl. They gave the name of *oil* to the inflammable principle of metals, of sulphur, and of charcoal, as well as to what is properly called oil. But the inflammable principle which enters into the composition of these bodies is only one of the constituent parts of oil; and oil cannot transfer this principle to any other body without being previously decomposed, and ceasing to be oil. *See* PHLOGISTON.

If any oil be distilled without an intermediate substance, at first a little acid phlegm arises, and afterwards the oil itself; and when a greater degree of heat than that of boiling water has been necessary to raise it, it always acquires an empyreumatic quality, so much stronger as the heat requisite to be employed was greater. This oil is always accompanied with an acid, which becomes more and more strong as the distillation advances. In the retort a small quantity of fixed and residuous coal remains. This coal, and also the soot of oil, are very difficultly combustible; but at length their whole inflammable principle may be burnt: then nothing remains but ashes, which, when well washed from any vestige of fixed alkali which they may contain, are a pure earth.

If the oil in the receiver be examined, we shall find that it is less in quantity than the oil originally employed; from which we may know that a quantity of oil has been decomposed by the operation. The water, acid, and earth evidently proceed from the decomposed portion of oil. Hence all oil contains

(*r*) Besides the principles or constituent parts of oil, mentioned in the text, we may add, that oils when decomposed by heat, or by mineral acids, emit a very large quantity of elastic vapor, or a kind of fixable air.

the principles mentioned in the definition. This is further ascertained by redistilling the same oil, by which another portion of it is decomposed, and the same principles are obtained. By repeating the operation a number of times, the whole oil may thus be decomposed into water, acid, earth. The phlogiston of the decomposed oil is dissipated in insensible vapors, which cannot be confined and collected, excepting that portion of it which remains fixed in the residuous coal.

An important remark may be made on these repeated distillations of oils, which is, that the undecomposed portion of oil which passes over into the receiver, becomes by each distillation more and more thin and volatile. But as oils chiefly differ from each other in greater or less fluidity and volatility, by repeated distillations, therefore, these differences are lessened, and all oils are approximated to a common state.

These experiments have not been prosecuted so far, as to enable us to determine the possibility of reducing all oils to one and the same state; but every thing inclines us to believe that possibility: and in this case we must conclude, that oil in its greatest purity and simplicity, and which might be called the *oily principle*, is essentially and identically the same in all vegetable and animal matters; and that the differences, although very numerous and considerable, betwixt the several kinds of oils, proceed only from the extraneous matters combined with them, by the mixture of which their essential properties are more or less altered, or disguised.

We have further another very important consideration upon this subject, to which we ought to attend, and which seems to counteract the opinion we have now explained. This is, that the greater thinness and volatility which oils have, either naturally, or by repeated distillations, the less soot they form when burnt, the less residuous coal they leave, and the stronger disposition they acquire to mingle together, or to dissolve in water; so that by continuing this attenuation of oils, they might probably be brought to the state of ether, and perhaps to that of ardent spirits, which certainly is essentially different from that of oils. Hence we learn, that by repeated distillations, oils are not only purified and rendered simpler, but are also essentially altered and changed.

All oils are also capable of alteration by the action of air, and by the concurrence of other circumstances which favor fermentation. The thinnest and most volatile part of them is dissipated; hence they become thick, and less volatile; and also the acid combined in oils thus exposed is more and more unfolded, and disengaged.

Acids have in general a power of acting upon oils. But the effects produced by their combination with them are very various, according to the nature of the acid, to its degree of concentration, and to the kind of oil.

Mineral acids, even the strongest, act in general but very weakly or not sensibly upon oils, when they are diluted in a large quantity of water; because this water with which they are more than saturated, and with which they have a strong affinity, prevents their acting efficaciously upon the water and phlogiston which are principles of the oil. But when they are concentrated sufficiently, they unite then to the principles of the oil, with a force proportionable to the degree of concentration of the acid, and to the affinity which it has with the inflammable principle, and with water.

Con-

Concentrated vitriolic acid attacks powerfully all the principles of oil, occasions an ebullition, considerable heat, and vapors, the smell of which is that of volatile sulphureous acid mixed with empyreuma. By this mixture, the color of the oil is changed to a brown, red, or blackish, and its consistence is rendered very thick.

The action of nitrous acid upon oils is still more vivid, more quick, and remarkable than that of vitriolic acid. From this mixture a more considerable quantity of vapors rise, the effervescence is much stronger, the thickening of the oil is sooner effected, and the heat is so great with most oils, that when the nitrous acid is much concentrated, the mixture becomes red-hot, and is instantly inflamed. *See* INFLAMMATION *of* OILS.

The action of even the most concentrated marine acid is very different from that of the vitriolic and nitrous acids upon oils; it is much weaker, and we may even say that marine acid does not form any union with oils.

The difference of the effects of these three acids upon oils evidently proceeds from the difference of their affinities with the inflammable principle: for we may observe a similar gradation in the action of these acids upon oils, and upon metallic substances.

As the several kinds of oils have their peculiar characters and properties, they also show considerable diversity in the phenomena exhibited by mixture with acids. We shall find some details on this subject under the several articles of the different kinds of oils. We shall only observe here, in general, that the vitriolic and nitrous acids are disposed to unite very intimately with all oils that are very thin, volatile, and inflammable. But these qualities make them even elude the action of the acids when much concentrated; for during the reaction, they are almost entirely, and sometimes instantly, dissipated in vapors.

The oils which are least thin and volatile, and which are disposed to thicken spontaneously by the evaporation of their most subtle parts (which property they owe to a certain quantity of resinous or gummy matter contained in them), are capable of sustaining all the action of acids, and therefore are the fittest to be inflamed by mixture with concentrated nitrous acid.

Lastly, all oils which have a certain degree of unctuosity and consistence, which are not volatile, nor disposed to thicken by evaporation, resist more the action of acids. They are not altered, nor are half decomposed, like the preceding oils, by acids. They unite with them more slowly and difficultly, and can only be thickened by the united action of the vitriolic and nitrous acids. By being united with these acids, they receive the character of an acid soap, or grease, as we shall see in the article of these oils.

The acids also are altered by combination with oils. We may say in general that acids are rendered weaker and milder by union with oils, and that this union approximates them to the character of vegetable acids, or even entirely assimilates them to these acids: so that if it be true, as we have reason to believe, that vegetables and animals are formed from minerals differently modified, the differences betwixt mineral acids, and the acids of the vegetable and animal kingdoms, must be attributed to the oily principle which the latter acids possess exclusively.

This opinion would be completely proved, if we could sufficiently simplify vegetable acids to reduce them to the quality of mineral acids, and particularly

of the vitriolic, or to transmute perfectly a mineral acid into a vegetable acid. But these important researches have not yet been made, or imperfectly, and not so fully as they deserve.

To transmute a mineral acid into a vegetable by uniting it with the oily principle, this union probably requires to be very intimate, without, however, altering in any measure the constituent parts of the oily matter. For if we employ the vitriolic or nitrous acid so much diluted that it shall not alter the oil with which it is to be united, many obstacles will then occur to prevent its intimate combination, the removal of which obstacles, however, we must acknowledge has not been sufficiently attempted; and on the other side, if acids be employed, so concentrated that they can act easily and effectually upon oils, they will then sensibly alter and half decompose them.

If we try, for instance, to separate by distillation the vitriolic acid from an oil with which it had been combined in its concentrated state, we shall only obtain from thence a very watery and sulphureous vitriolic acid; a certain quantity of empyreumatic and sulphureous oil; a stronger vitriolic acid, but still sulphureous; a thick and bituminous empyreumatic oil; sulphur which will be sublimed to the neck of the retort; and lastly, a fixed and residuous coal, more abundant than would have proceeded from the oil, if it had been distilled alone.

In this experiment we evidently see that a part of the oil is decomposed, that the vitriolic acid is not otherwise changed than by becoming sulphureous, and that it is consequently not approximated to the nature of vegetable acids. *See* ACID SULPHUREOUS, *and* SULPHUR.

The great quantity of water mixed with the first portion of acid which rises, is certainly a part of the watery principle of the oil, since the acid employed was concentrated. This acid becomes sulphureous, and forms sulphur, from the union it contracts with a part of the phlogiston of the oil. Lastly, the residuous coal is more considerable in this distillation, because a larger quantity of earthy principle is separated from the other constituent parts of the oil, and particularly from the watery part. The small portion of the vegetable acid obtained in the distillation of oils without addition, does not appear in the present experiment, because it is disguised, or even decomposed, by the vitriolic acid.

I do not know that mixtures of concentrated nitrous acid with oils have been distilled; but probably phenomena similar to those we have mentioned would happen, with those differences only which would be occasioned by the particular properties of that acid.

Of all the experiments hitherto made on the combinations of mineral acids with inflammable matters, those concerning the mixtures of mineral acids with spirit of wine seem to promise most success for the transmutation of these acids into vegetable acids; because the mineral acids are very intimately united with the principles of the spirit of wine; because these acids are necessarily diluted with the water which is a constituent part of the spirit of wine, and which is in much larger quantity than in oils; and lastly, because the action of acids upon spirit of wine is such, that it entirely approximates that spirit to the nature of oil, altho' the inflammable principle of spirit of wine be not in an oily state, and although all vegetable acids do manifestly contain an oil. Accordingly, if

we would proſecute this aſſimilation of mineral acids to vegetable acids, the beſt method ſeems to be by treating them with ſpirit of wine. *See* SPIRIT *of* WINE, ETHER (VITRIOLIC, *and* NITROUS).

All oils diſſolve ſulphur, and form with it a compound, called *balſam of ſulphur*. The connexion of phlogiſton with vitriolic acid ſeems to be much weakened in the ſulphur by the intervention of oil; for if balſam of ſulphur be diſtilled, the ſulphur will be totally, or in great meaſure decompoſed, ſince only the ſame principles are obtained by this diſtillation as are obtained by diſtilling the combination of the oil with vitriolic acid. *See* BALSAM *of* SULPHUR *and* SULPHUR.

Alkalis act upon all oils, and combine with them to a certain degree, but more or leſs readily, according to the nature of the oil. In general, the leſs thin and volatile any oil is, the more eaſily ſoluble is it by alkalis; and reciprocally.

From the combination of an alkali with an oil reſults a compound more or leſs thick, called *ſoap*. The oil which enters into the compoſition of ſoap becomes eaſily miſcible with water by means of the alkali, but is not perfectly diſſolved in water; for the ſolution of ſoap has always a white milky appearance; which ſhews that the oil of ſoap diſſolved in water is in a ſtate ſimilar to that of an emulſion. This proves at the ſame time that the combination of oils with alkalis is not intimate; accordingly the oil receives no alteration, or ſcarcely any from the alkalis: for it may be ſeparated by means of any acid, and then it is found to be in the ſame ſtate it was in before its entry into the ſoap. *See* SOAP.

Oils may be united with metallic ſubſtances. They attack moſt ſenſibly copper and lead. Oils diſſolve copper even without heat, and from this ſolution reſults a blueiſh-green ſhining matter. The action of oils upon this and other metals is probably by means of their acid and phlogiſton. The concurrence of the air perhaps facilitates this ſolution; perhaps even it is neceſſary.

Oils are moſt eaſily combinable with the calxes of lead, as minium, ceruſs, and litharge, probably becauſe theſe preparations are much divided, and the oils which have the greateſt diſſolving power are thoſe which are the leaſt thin and leaſt volatile. When the calxes of lead are united only in ſmall quantity with oil, they do not deſtroy its fluidity, but diminiſh it, and give to the oil the property of drying much more readily.

Theſe oils, called *drying oils*, are much uſed in painting, from their drying quality. When a large quantity of calxes of lead is combined with oil, they form with it a ſolid, opake, and tenacious body, capable of ſoftening by heat. Theſe combinations are uſeful in pharmacy, for giving a convenient conſiſtence and tenacity to many plaſters. Mr. Geoffroy has obſerved, that calxes of lead combined with oils form compounds which have ſome ſaponaceous characters; that they communicate to water nearly the ſame taſte and unctuoſity that ſoap does, and make it lather in the ſame manner; that the oil may be ſeparated from the lead by means of acids, in the ſame manner as alkaline ſoaps may be decompoſed; and that the oil thus ſeparated is entirely ſimilar to that obtained by decompoſing ſoaps. Theſe combinations of oils with metallic ſubſtances have been examined but ſuperficially by chemiſts; nevertheleſs, they

present very interesting observations and particulars. We now proceed to the several kinds of oils.

CCCCLXXXVII. OILS (ANIMAL). All animal substances contain an oil, which is naturally unctuous, mild, and not volatile with the heat of boiling water. But, in general, the oil obtained from animals is in two very different states, which ought to be distinguished from each other.

The first state is that of butter and fat. This kind of animal oil is thick or congealed, and owes this quality to a considerable quantity of acid intimately combined with it, and which cannot be unfolded but by the action of fire, or by the rancidity it contracts in time.

The oil of animals, which is in form of butter or fat, is not combined with the other principles of animal matters. It is distinct from them, is superabundant to the animal composition, and is of a nature totally different from that which is combined with the animal substances. This superabundant animal oil, which may be called *adipous oil*, resembles perfectly wax, and those vegetable oils called properly *fat oils*; and, like these, it contains no other saline substance than an acid. The acid of these oily matters is more intimately combined than in other kinds of oils. Hence they are much less apt to become rancid, furnish less acid by repeated distillation, and are by this operation most difficultly rendered thin and volatile. *See* BUTTER, WAX, FAT, *and* OILS (FAT).

The oils of this kind which are contained in animals are fat, marrow, the expressed oil of yolks of eggs, spermaceti, and others of this nature.

The second state, in which the oil of animals is found, is in that of combination. The substance which forms almost entirely all the parts composing animal bodies, as flesh, tendons, nerves, cartilages, bones, horns, hair, &c. is gelatinous, perfectly soluble in water, and which does not disturb the transparency of water. This matter being distilled, furnishes a large quantity of oil, which is one of the parts of the decomposed substance. *See* JELLY. As this oil does not appear in the gelatinous matter before it has been decomposed; and as this matter is perfectly soluble in water, we may infer that oil is one of the principles of jelly, and is rendered perfectly miscible with water by means of the saline principles of that matter; it is consequently in a state perfectly saponaceous.

When the gelatinous matter has received no alteration, the oil which it contains appears absolutely mild, and is not so volatile as to rise with the heat of boiling-water; for fresh animal matters furnish nothing by distillation with that heat but water, excepting those which have peculiar smells, as musk, castor, and others of that nature. But if a stronger heat be applied, they then furnish much volatile alkali, and an oil; the first portions of which are thin, penetrating, and volatile. This is the oil which ought to be considered as the true animal oil. It has a smell strongly empyreumatic, disagreeable, and mixed with that of volatile alkali. This oil becomes more and more thick as it rises in distillation, as is usual in the distillation of all oils.

This animal oil differs essentially from fat, and from all vegetable oils. The cause of this difference seems to be, that the former oil does not appear to furnish a single particle of acid, but rather volatile alkali; whereas the latter oils contain an acid, which is unfolded and separated by distillation.

CCCCLXXXVIII. OIL (ANIMAL) RECTIFIED, *or* OIL *of* DIPPEL. The animal oil described in the preceding article is susceptible, as other oils are, of being attenuated, and rendered more volatile, by repeated distillations. By a sufficient number of successive distillations, it may be rendered almost as white, thin, and volatile as ether. It is discovered to acquire a property of acting upon the brain and nervous system, and of allaying its irregular movements; which property is common to it with all other inflammable matters, when highly attenuated and very volatile. But this oil is particularly recommended for epileptic and convulsive affections. It is given from four to ten or twelve drops, incorporated with some proper vehicle.

The animal oil designed for medicinal uses must have the above-mentioned thinness, as Dippel has observed, whose name it retains: but it is then very dear, from the long and troublesome operations requisite to give it that thinness, and from the smallness of the quantity obtained. Besides, this oil, although perfectly well prepared, is very susceptible of losing its whiteness, and even its thinness, by a short exposure to air; which proceeds from the almost instantaneous evaporation of its more thin and volatile parts, and from the property which the less volatile remainder has of acquiring color. To avoid this inconvenience, it must be put, as soon as it is made, into very clean glass bottles, with glass stoppers, and exposed as little as possible to the air.

Although all animal substances contain this oil, they are not all equally fit for furnishing by distillation an oil capable of being rectified into a good oil of Dippel. For this purpose we ought to choose the parts of animals which contain the purest gelatinous substance, and which are entirely free from all fat; for the oil of fat, which necessarily mixes with the other oils in distillation, contains, as we have observed under the article OIL (ANIMAL), a large portion of acid intimately combined with it, from which it is very difficultly separable, and therefore is not nearly so easily attenuated as the true animal oil; besides that one of these oils has an acid, and the other an alkaline quality, and therefore their medicinal effects are probably different. Accordingly, as the flesh, bones, blood of animals, contain always some oily substance of the nature of fat or marrow, they ought not to be chosen for the preparation of the oil of Dippel. Horns, and particularly those of stags, which contain very pure gelatinous matter, are the animal substances from which the greatest quantity of this oil can be obtained in good condition.

The most important observations concerning the method of making the oil of Dippel are: First, to change the vessels each distillation, or else to clean them perfectly; for a very small quantity of the thicker and less volatile part is sufficient to spoil a large quantity of that which is more rectified. In the second place, Mr. Beaumé has observed, that this operation may be greatly abridged by taking care to receive none but the most volatile part in each distillation, and to leave a large residuum, which is to be neglected, and only the more volatile part is to be further rectified. By this method, we may obtain in three or four distillations a considerable quantity of fine oil of Dippel, which could not be obtained after 50 or 60 distillations, without attending to this circumstance.

CCCCLXXXIX. OILS (SWEET) *obtained from* VEGETABLES *by* EXPRESSION. Vegetable matters, at least many

many of them, contain an oil in two different ſtates, as animal matters alſo do; that is, in vegetables a certain quantity of oil is ſuperabundant to their combination, does not enter into the compoſition of their proximate principles, is diſtinct, and is depoſited as a reſerve in different parts of plants; and alſo in vegetables another quantity of oil is combined, and is one of the conſtituent parts of their proximate principles. Such are the ſaponaceous extractive ſubſtance, acids, eſſential ſalts, mucilaginous matters. Of the former of theſe vegetable oils we treat in this article. This ſuperabundant and uncombined oil, which may be obtained from certain vegetables, may be diſtinguiſhed into two kinds; one of which is acrid, volatile, and odoriferous, and is called *eſſential oil*; the other kind is mild, is not volatile with the heat of boiling water, and has ſcarcely any ſmell. Of this latter we ſhall firſt treat.

Moſt grains and kernels are the particular reſervoirs of this ſuperabundant oil. If theſe ſubſtances be bruiſed and pounded, this oil appears, and exſudes from them. By triturating them with water, the oil is reduced into the ſtate of an emulſion; and by expreſſing them, a very large quantity of oil is forced out of them.

When the grains and kernels from which oil is thus extracted are recent and preſerved from rancidity, the oil obtained has a very mild taſte. It is at firſt a little turbid, by mixture of ſome of the other parts of the grain or kernel; but theſe matters afterwards ſeparate in form of ſediment, and the oil becomes clear.

Theſe oils are never very fluid and thin; on the contrary, they are conſiderably unctuous. They are not ſo volatile as to riſe in diſtillation with the heat of boiling water, as we have already ſaid; and when they are expoſed to a heat ſo ſtrong as to raiſe them into vapors, they then ſuffer a conſiderable alteration. Although they are mild and inodorous, yet by diſtillation they become very acrid and very empyreumatic. Although they are combuſtible, yet they cannot be inflamed merely by the touch of a kindled body, as all thoſe inflammable matters may, which, by their volatility, are continually evaporating. Expreſſed oils cannot be inflamed without a wick, or without a heat ſufficient to evaporate them.

Sweet expreſſed oils ſuffer by time ſeveral alterations; they loſe much of their mildneſs, contract an acrimony, and a ſtrong ſmell. Theſe changes, which are called *rancidity*, are occaſioned by a kind of internal fermentation, which produces effects ſimilar to thoſe of fire, but much more ſlowly and weakly. The acid which is intimately combined with theſe oils, and which does not ſhow itſelf when they are recent and have not been altered, diſengages itſelf more and more as they become old, in the ſame manner as it does by expoſure to fire. This is the reaſon why they become acrid in both caſes: for the ſame reaſon alſo, they acquire ſo much greater ſolubility in ſpirit of wine, (which they had not before) as they have become more rancid, or have been more frequently diſtilled. Mr. Macquer has ſhewn, in his Memoir concerning the Difference of Solubility of Oily Subſtances in Spirit of Wine, that this entirely depends on the ſtate of the acid of theſe ſubſtances; that they are ſo much more ſoluble as their acid is more copious and diſengaged; and reciprocally. We ſhall find ſome particulars upon this ſubject at the article Essential Oil.

Of all oils, those of which we now treat are the most proper for combining with fixed alkalis, and for forming good soap (*see* SOAP); and also for dissolving metallic matters.

All the sweet superabundant oils in vegetables, and which are capable of being extracted merely by expression, resemble each other by the general properties we have mentioned: but they differ considerably from each other by the degree in which they possess these and other properties. Some of these oils, as of linseed, nuts, hempseed, are disposed to become rancid, to thicken, and to dry very quickly; they are capable of resisting a great degree of cold without being congealed; they form resinous comppunds when mixed with vitriolic and nitrous acids, and are easily inflamed by the smoking nitrous acid, as Mr. Rouelle has observed. Other oils, as those of ben, olives, sweet almonds, wallnut, &c. become much more slowly rancid and thick; they cannot be entirely dried; they congeal with a very slight degree of cold; they are less disposed to combine with the vitriolic and nitrous acids; they form with these acids compounds, which rather resemble fat or soap, as Mr. Béaumé remarks, than resins; and, lastly, cannot be inflamed, but by the concurrence of the vitriolic and nitrous acids highly concentrated. As these latter oils have, as to consistence, a perfect resemblance to *butter*, *fat*, and *wax* (*see these words*); and as they exhibit entirely the same phenomena, they justly deserve to be distinguished from all others by the particular denomination of *fat oils*.

In the class of these latter oils, we may range some concrete, oily, and mild matters obtained from vegetables; such are the *butter of cacao*, the *green wax of Louisiana*, and perhaps many others hitherto not sufficiently examined. We may easily perceive, that among the great number of sweet oils obtained by expression, and which are not volatile, several of them must more or less partake of the nature of one or other of the two principal kinds we have just mentioned.

CCCCXC. OILS (ESSENTIAL). Those oils are called *essential*, which have evidently the smell of the vegetable from which they are obtained. All these oils are sufficiently volatile to rise with the heat of boiling water: hence this degree of volatility is one of the specific marks of these oils. They differ from all others, and particularly from those mentioned in the preceding article, by this degree of volatility, which is peculiar to them.

We have reason to believe, that the greatest part of the essential oil, which certain vegetables contain, is in a state of combination, and makes part of some of their proximate principles. We are, however, certain, that many vegetables contain a superabundant essential oil, uncombined, and deposited as a reserve in particular cells: such is the oil which resides in the rinds of oranges, lemons, citrons, in a word, of all fruits of that kind; which oil is so copious, that it may be obtained merely by expression; such probably are those which are found most copiously and most manifestly in certain parts of plants; as the oil, for instance, which is found in the calix of roses, but in too small a quantity to be obtained by expression alone.

However that be, as all essential oils are capable of rising in distillation with the heat of boiling water; and as this degree of heat cannot occasion any sensible alteration upon them (as may easily be seen by comparing the essential oil of citrons and others, obtained by expression alone, with the oil of the

vegetable

vegetable extracted by a well managed diſtillation); by ſuch a diſtillation, therefore, may be obtained almoſt all the eſſential oils employed in chemiſtry and in the arts.

The moſt uſual and beſt method of obtaining the eſſential oil of a vegetable by diſtillation, is to take the plant in its prime of age, when its ſmell is the ſtrongeſt, and to chuſe thoſe parts of the plant in which the ſmell chiefly reſides; to put them in the cucurbit of an alembic without a water-bath; to add as much water as is ſufficient to prevent the plants from touching the bottom of the veſſel; to adjuſt a worm to the noſe of the alembic; and to give at once the degree of heat which is proper to make the water boil.

In this diſtillation, the water riſes impregnated with the ſmell of the plant, and it carries along with it all its eſſential oil. A part of this oil is ſo intimately mixed with the water which riſes in diſtillation, that it renders it turbid and milky; the reſt of the oil floats upon the ſurface of the water, or ſinks to the bottom, according to its ſpecific gravity. The diſtillation is thus to be continued, till we perceive that the water becomes clear; and more water muſt, from time to time, be put into the cucurbit, that the plant may be always kept moiſt with it. We ſhall ſee the reaſon of the ſeveral parts of this proceſs in the explanation of the particular properties of eſſential oils.

Not only theſe oils have all a ſtrong, aromatic ſmell, as we have already ſaid, but they have alſo a ſingular, and even an acrid and cauſtic taſte; in which reſpect they differ from the ſweet oils. This taſte proceeds from a copious and diſengaged acid, with which they are all penetrated.

The preſence of this diſengaged acid in eſſential oils appears from the impreſſion they make upon the corks of bottles, in which they are kept. Theſe corks are always ſtained of a yellow color, and a little corroded, nearly as they are by nitrous acid. Beſides, the vapor of theſe oils reddens blue paper; and the oils convert alkalis, with which they are triturated, into a neutral ſalt.

This acid is the cauſe of the ſolubility of eſſential oils in ſpirit of wine. They are not all equally ſoluble in this menſtruum, becauſe they do not all contain an equal quantity of acid. As this acid is almoſt diſengaged, and does not adhere ſtrongly in theſe oils, they loſe much of it by repeated diſtillations, and therefore their ſolubility in ſpirit of wine is leſſened by theſe operations; whereas ſweet oils, which, when recent, contain no diſengaged acid, and are therefore inſoluble in ſpirit of wine, become ſoluble in that menſtruum by diſtillation, which diſengages their latent acid, that was intimately combined with them; and this ſolubility may be encreaſed by repeating many times the diſtillation, as Mr. Macquer has proved in the Memoir quoted in the preceding article.

All eſſential oils are ſubject to loſe, by evaporation, their moſt volatile and thin part, in which the ſpecific ſmell of the vegetable, from which they are obtained, reſides; by which loſs they become thick, and acquire the conſiſtence and ſmell of turpentine, or even of reſins.

When in this ſtate, they are not, properly ſpeaking, eſſential oils, as they are no longer volatile with the heat of boiling water.

When eſſential oils, altered by time, but not yet entirely deprived of their peculiar ſmell, are diſtilled with the heat of boiling water, a part of them riſes in diſtillation, which has all the properties of eſſential oil freſhly diſtilled. As

this portion of oil is renewed by this operation, it is frequently practised on essential oils, which begin to be altered by age; and this second distillation is called the *rectification of essential oils.* We find in the cucurbit, after rectification, the resinous portion of the oil, which is no longer capable of being raised by the heat of boiling water. This oily residuum may, however, be attenuated by distilling with a stronger heat, and even all the volatility and thinness of essential oils may be given to it, as also to all other oily matters, by distillations sufficiently repeated. But such oils have never the peculiar aromatic smell of the original essential oil.

From these properties of essential oil, we may conclude, that they receive their specific character from their volatile odoriferous principle, that is, from the *spiritus rector* of the substance from which they were obtained; since they have the smell, thinness, and volatility which distinguish them, while they preserve this principle, and lose all these properties when it evaporates.

These facts also shew the necessity of applying very quickly the degree of heat requisite for the raising of these oils in distillation; for we may easily perceive, that as the spiritus rector is capable of rising with a heat much less than that of boiling water, (which is necessary for raising essential oils) this spirit will rise alone, when the heat is less than that of boiling water, and the quantity of essential oil obtained will be diminished; so that if the distillation be continued with a less heat than that of boiling water, till the plant has lost all the smell which it can lose by this heat, no essential oil can then be obtained, or only a much less quantity of it.

As the spiritus rector is entirely soluble in water, therefore the water employed in this distillation of essential oils dissolves a large portion of this spirit, and even becomes saturated with it. Accordingly, this water is much impregnated with the smell of the plant; but the oil by this means is in less quantity than it otherwise would be.

Hence we may infer, first, that no more water than is necessary ought to be employed; and, secondly, that the water which has thus risen with the oil ought to be employed for other distillations preferably to pure water.

This water is not only much impregnated with the odoriferous principle of plants, but also it contains a considerable quantity of the thinnest part of the essential oil, from which it receives a milky appearance. This portion of oil sometimes remains a long time suspended and half-dissolved, by means of the spiritus rector: but, in time, a certain quantity of it is always separated, which may be collected.

Essential oils are in general the most inflammable of all oils, because they are the most volatile, and most easily reducible into vapors.

They unite more easily with acids than the sweet oils which are not volatile. With these acids they form resinous compounds, or are inflamed, according to the nature and degree of concentration of the acid employed.

They are more difficultly combinable than the sweet oils which are not volatile, with fixed alkalis, with which they form a particular kind of soap. *See* SOAP *of* STARKEY.

Some considerable differences may be observed betwixt the several essential oils. Although, in general, they are all capable of rising with the heat of boiling water, some of them, however, may be obtained in a larger quantity by

a heat ſomewhat ſtronger; and this is effected by mixing with the water ſalts (as common ſalt) which are incapable of acting upon oils, and by means of which the water is capable of receiving a ſtronger heat.

The ſpecific gravity of moſt of theſe oils is leſs than that of water, and accordingly they float upon the ſurface of this liquid. Some of theſe oils, however, are ſo heavy as to ſink in water; of this kind are the eſſential oils obtained from the aromatic vegetables of hot countries, as cloves, cinnamon, ſaſſafras, &c. To the diſtillation of theſe heavy oils a ſtronger heat is chiefly uſeful. Dry, woody, and compact matters, previouſly to the diſtillation of their eſſential oils, require the aſſiſtance of diviſion and maceration during ſome days.

The conſiſtence of eſſential oils varies much; ſome of them, as thoſe of turpentine, ſaſſafras, and citron, being very thin; and others, like thoſe of aniſeed and roſes, have naturally much conſiſtence, and are even congealed, unleſs they ſuſtain a certain degree of heat.

Although the weight and conſiſtence of eſſential oils proceed probably from the ſtate of their acid, as well as all the other differences betwixt them, yet theſe two properties ſeem to be independent of each other; for ſome oils are, at the ſame time, very thin and very heavy, while others are very light and thick. The oil of ſaſſafras, which is very fluid, is heavier than water; on the contrary, the oil of aniſeed, the conſiſtence of which is ſometimes equal to that of congelation, floats upon water.

The quantity of eſſential oil obtained from different vegetables is very various. Some vegetable ſubſtances, as ſavin, turpentine, and moſt balſamic and reſinous trees, furniſh a large quantity of oil. From others, as roſes, for inſtance, ſcarcely a ſenſible quantity of it is obtainable; and, laſtly, others, although they contain much ſpiritus rector, and have much ſmell, furniſh no eſſential oil by diſtillation: of this number are lillies, tuberoſes, and jaſmine.

Eſſential oils are employed in painting, in ſpirituous liquors uſed at the table and at the toilette, in perfumes, and in medicine. As they act very powerfully, ſmall doſes only are given internally, as from one drop to four or five, incorporated with ſugar, ſo as to form an oleoſacharum, or with other drugs in form of pills.

Theſe oils being inflammable, thin, and volatile, have in general a property of acting upon the nervous ſyſtem, and of allaying its irregular movements: it is therefore given as a cephalic, and antiſpaſmodic, in convulſive and hyſterical affections; they are alſo ſtimulant, ſudorific, and ſtrengthening. All drugs which are alexipharmac, cephalic, tonic, and ſtomachic, which contain vegetable aromatics, derive their virtues from the eſſential oils of theſe vegetables. The ſame may be ſaid of all medicinal, aromatic, and ſpirituous waters.

In ſome caſes, eſſential oils are employed externally as ſtrengtheners, and to allay painful ſpaſms of nervous and tendinous parts, to reſolve and diſſipate acrid humors, which occaſion pain without any ſenſible ſign of inflammation. When eſſential oils are applied externally in theſe caſes, they are ſo cauſtic that they muſt not be applied alone, as they would excite pain, redneſs, frequently inflammation, eryſipelatous eruptions, and excoriations. They are a kind of veſicatory. The beſt method of avoiding theſe inconveniences is, by mixing them

them with a ſufficient quantity of fat, or of fat oil, to form liniments or pomatums, with which the diſeaſed parts may be rubbed.

The eſſential oils, which are obtained from ſcarce and valuable ſubſtances, muſt alſo be very dear, and are therefore ſubject to much adulteration. Moſt of the books of chemiſtry explain the manner of making, or of diſcovering theſe adulterations. We ſhall only, in a ſummary manner, mention what is moſt important to be known on this ſubject.

Eſſential oils may be adulterated with any flavorleſs fat oil, with ſpirit of wine, or with any common and cheap eſſential oil. They who know the properties of theſe ſubſtances may eaſily diſcover the fraud. As fat oils are neither volatile nor drying, if a drop of the eſſential oil, to be examined, be put upon paper, it may be evaporated with a gentle heat; and when it is unmixed with fat oil, it will leave no greaſineſs nor tranſparency in the paper. This mixture may alſo be diſcovered by mixing a drop of the eſſential oil with ſpirit of wine, by which it will be entirely diſſolved if it be pure from fat oil; but if it has been adulterated with this latter kind of oil, this will remain undiſſolved in ſpirit of wine.

The mixture of ſpirit of wine with an eſſential oil may be diſcovered by addition of water, which immediately acquires a milky appearance; becauſe the ſpirit of wine quits the oil to unite with the water, and leaves the oil much divided and ſuſpended, but not diſſolved. This does not happen when the eſſential oil has not been adulterated with ſpirit of wine. Pure eſſential oil may, indeed, by agitation with water, be divided into ſmall globules, and may give a whiteneſs to the water: but theſe globules quickly unite again on the ſurface, or at the bottom of the water, according to their ſpecific gravity.

Laſtly, adulteration by another eſſential oil is moſt difficultly diſcoverable; becauſe the principal properties of theſe oils are common to all. Nevertheleſs, as eſſential oils are commonly adulterated with oil of turpentine, this fraud may be diſcovered by ſoaking a bit of paper or linen with the oil to be examined, and by quickly evaporating the oil, which will leave upon the linen or paper a ſtrong ſmell of turpentine.

CCCCXCI. OILS (FETID, EMPYREUMATIC). Under this name we comprehend all the oils of vegetable and animal matters obtained by diſtillation with a heat ſuperior to that of boiling water; becauſe theſe oils have a diſagreeable, burnt, or empyreumatic ſmell.

From this definition we ſee, that empyreumatic oils are not a diſtinct claſs; that they may be very different from each other, and may have nothing in common, but that they are all half-burnt; for when any vegetable or animal matter is expoſed to a degree of heat ſuperior to that of boiling water, all the oils which they contain, of whatever kind they may be, paſs in diſtillation; but are altered, by the fire, in their color, ſmell, and in many other of their peculiar properties. Beſides, if the matter thus diſtilled contains ſeveral kinds of oils, they are all mixed together when they are rendered empyreumatic. If, for example, a vegetable matter be diſtilled, which contains an oil that is ſweet and not volatile, and alſo an oil in a reſinous ſtate, the fetid empyreumatic oil obtained will be only a mixture of theſe two oils half-burnt. The ſame may be ſaid of animal matters with regard to the oil properly called animal oil, and to the adipous oil which they contain.

No general properties, then, can be eſtabliſhed as belonging to empyreumatic oils: they all vary according to the nature and proportion of the oils of which they are compoſed. Hence, if we would know the properties of any empyreumatic oil, we muſt previouſly know the kinds and proportion of oils contained in the ſubſtance from which it has been obtained, and alſo the changes ſuffered by each of theſe oils by the degree of heat requiſite to render them empyreumatic. We ſhall here only obſerve, that all empyreumatic oils are acrid, and more or leſs ſoluble in ſpirit of wine; that the portion of theſe oils which riſes firſt in diſtillation is always the thinneſt; that by repeated diſtillations they may be rendered more and more thin and volatile; and that by a ſufficient repetition of theſe rectifications, we may almoſt entirely deprive them of their empyreumatic ſmell, ſo that only a pungent and penetrating ſmell ſhall remain; which ſeems to be common to all oils treated in this manner.

CCCCXCII. OILS, *improperly ſo called.* Many preparations were by the ancient chemiſts called *oils*, merely from their conſiſtence, although in other reſpects they were entirely different from oil. Theſe improper names ought to be aboliſhed, and they are accordingly falling into diſuſe by modern chemiſts. Nevertheleſs, as they are found in moſt chemical books in the time of Lemeri, and as many of them are ſtill frequently employed, we ſhall explain in a few words the chief of them.

CCCCXCIII. OIL *of* ANTIMONY. By this name the butter of antimony, and ſome other ſolutions of antimony by acids, are called. *See* BUTTER *of* ANTIMONY.

CCCCXCIV. OIL *of* ARSENIC. This is a combination of concentrated marine acid with arſenic, and is made preciſely in the ſame manner as butter of antimony. Equal parts of arſenic and of corroſive ſublimate are mixed and diſtilled together, by which a liquor is diſtilled, ſimilar to the butter of antimony. This is a very powerful, but, at the ſame time, very dangerous cauſtic. This ſhews, that arſenic, like regulus of antimony and ſeveral other metallic ſubſtances, is capable of decompoſing corroſive ſublimate by ſeizing its acid. Accordingly, mercury is revived in this as in all the ſimilar operations.

CCCCXCV. OIL *of* MERCURY. When water is added to a ſolution of mercury in vitriolic acid to form the precipitate called *turbith mineral*, the acid thus diluted ſtill retains a portion of mercury diſſolved, which is properly a vitriol of mercury. This ſalt, which is cryſtallizable, may be obtained by evaporating the water which keeps it diſſolved. When expoſed to a moiſt air, it deliquiates into a liquor which Lemeri calls *oil of mercury*. *See* TURBITH MINERAL.

Lemeri alſo gives the name of *oil of mercury* to a ſolution of corroſive ſublimate in ſpirit of wine.

CCCCXCVI. OIL *of* LEAD. This is a ſolution of ſalt of lead in the eſſential oil of turpentine. This ſalt is to be put into a matraſs, and upon it oil of turpentine is to be poured, till it covers the ſalt with a thickneſs of ſome fingers, and the whole is to be digeſted during ten or twelve hours. The liquor, ſays Lemeri, acquires a red color. That author directs, that the ſolution ſhould be concentrated, by diſtilling from it a part of the oil of turpentine; and he recommends it for its utility in cleanſing and cicatriſing ulcers, particularly

ticularly those which are putrid. This preparation, which is certainly a powerful antiseptic, must be very proper for these purposes.

Amongst the oils improperly so called, this is one of those to which the name of oil has been with least impropriety given; for the basis of it is actually oil, and that oil really keeps the lead in solution. Lemeri affirms, that we may thus entirely dissolve a given quantity of salt of lead, by employing a sufficient quantity of oil of turpentine. This preparation, which has only been made for medicinal purposes, is interesting also in chemistry, and deserves a particular examination.

CCCCXCVII. OIL *of* SULPHUR. Some chemists have given this name to the concentrated acid of sulphur. *See* SULPHUR.

CCCCXCVIII. OIL *of* TARTAR *by* DELIQUIUM. This name very frequently is given to fixed alkaline salt resolved into a liquor by the moisture of the air, or even to a solution of that salt in water. This name is unsuitable, not only as this liquor is not of the nature of oil, but also because a true oil of tartar is obtained by distillation of tartar. This liquor ought to be called *alkali of tartar*, or *liquid vegetable alkali*. *See* ALKALI (FIXED VEGETABLE), *and* TARTAR.

CCCCXCIX. OIL *of* VENUS. Lemeri gives this name to the salt formed by the union of copper with the nitrous acid, when it is resolved into a liquor by the moisture of the air. It is a caustic and escharotic, like all other similar combinations of metallic matters with any acids to which the name of oil was formerly given. An empyrical physician has rendered this name of oil of Venus famous in these latter times, by having applied it to a ratafiat of his composition, which has been found agreeable, and has been much in vogue.

D. OIL *of* VITRIOL. This name is very commonly, but improperly, given to concentrated vitriolic acid. *See* ACID (VITRIOLIC), *and* VITRIOL.

DI. OLEOSACHARUM. This name is given to a mixture of oil and sugar incorporated with each other, to render the oil more easily diffusible in watery liquors. Sugar and all saccharine matters have in general a quality somewhat saponaceous, and consequently are capable of producing this effect in some measure. These oleosacharums are used in pharmacy as a method of administering essential and other oils. *See* OILS *and* JUICES (SACCHARINE).

DII. OLIBANUM. *(s)*

DIII. ONIONS. *(t)*

DIV. OPAL. *(u)*

(s) OLIBANUM, *thus*, *frankincense*, is a gum-resin, of an ounce of which water is capable of dissolving three drams and a scruple, and spirit of wine is capable of dissolving five drams and two scruples. *Neuman.*

(t) ONIONS. This root has an essential oil, which impregnates water in distillation with a very strong smell, and which is so miscible with the distilled water, that it cannot be collected separately. The oil may also be combined with spirit of wine by distillation. From an ounce of the dry root six drams of extract may be obtained by spirit of wine, and somewhat more may be obtained by water. *Neuman.*

(u) OPAL is an almost pellucid agate, the color of which varies by reflexion and refraction. Opals are milk-colored, blackish, yellowish, or greenish; which latter variety

DV. O N Y X. (x)

DVI. O P I U M. (y)

DVII. O P O P O N A X. (z)

DVIII. O R A N G E. (a)

DIX. O R E S. Ores are natural compounds, containing metals allayed with different ſubſtances.

Excepting gold, and a very ſmall quantity of each of the other metals found in ſome places ſo pure as to poſſeſs all their characteriſtic properties, nature exhibits to us metals and ſemimetals differently allayed not only with each other, but alſo with ſeveral heterogeneous ſubſtances, which ſo alter and diſguiſe their qualities, that in this ſtate they cannot ſerve for any of the purpoſes for which they are proper when they are ſufficiently pure.

The ſubſtances found naturally combined with metals, in the earth, are, particularly, ſulphur and arſenic, ſometimes ſeparately, but generally conjointly.

is called *cats eye*. Opals are claſſed among the ſiliceous order of earths, although ſome of them are ſo ſoft as to be capable of being ſcratched with a knife. The *oculus mundi* is a rare but curious variety of the opal. It is opake, and generally of a yellowiſh color; but by being immerſed during ſome hours in water, becomes tranſparent, and acquires a bright yellow, or even a luminous flame-color.

(x) ONYX is an agate, generally opake, or but ſlightly tranſparent, conſiſting of differently colored veins, parallel to each other, ſometimes in ſtraight and ſometimes in curve lines. *See* AGATE.

(y) OPIUM is almoſt totally ſoluble in water or in ſpirit of wine. It contains a reſin, a gum, a minute portion of ſaline acidulous matter, water, and earth. On what its peculiar properties depend we do not well know. When opium is diſſolved in water, a fat, frothy, reſinous ſubſtance riſes to the ſurface, which is ſo ſtrong and active, that a few grains of it are ſufficient to kill a dog who could bear a whole dram of opium. From a pound of opium two or three drams only of this ſubſtance may be collected; but the opium contains more of it, which remains combined with the reſt of the juice. The narcotic matter of the opium appears to be diffuſed through all its ſubſtance, but more eſpecially to reſide in the fine volatile parts; which parts are capable of being highly concentrated by art. Neuman (from whom the above is extracted) ſays, that he knows a preparation of opium by which a whole chamber full of men may be preſently ſtupefied, deprived of their ſenſes, and even of their lives, without ſwallowing a ſingle grain. He thinks that it operates nearly in the ſame manner as the vapor of burning charcoal, or as the exhalations of fermenting liquors. The ſame author propoſes to render opium more mild and innocent, by diſſolving it in water and fermenting the ſolution. Dr. Lewis obſerves, that diminiſhing the doſe of opium is a more certain method of diminiſhing its effects. He alſo ſays, that alkaline ſalts diminiſh the ſoporific power of opium, and that acids almoſt totally deſtroy it.

(z) OPOPONAX is a gum-reſin, of an ounce of which two drams and two ſcruples are ſoluble by ſpirit of wine, and three drams two ſcruples are ſoluble by water. Both water and ſpirit, by diſtillation with opoponax, acquire its flavor; but no oil is thereby ſeparated. *Neuman*.

(a) ORANGE. The flowers of orange trees afford, by diſtillation, a very fragrant eſſential oil. From the rind of the fruit an eſſential oil may be obtained by expreſſion. The juice of the fruit contains an eſſential acid ſalt, mixed with much mucilage. This ſalt may be obtained in cryſtals, by diluting the juice, clarifying it with whites of eggs, and evaporation. The juice, not depurated from its mucilage, is apt to become mouldy; but by the above-mentioned method of depuration, a ſaline extract may be made, capable of being preſerved, and poſſeſſed of the ſame medicinal qualities as the juice, which is ſaid to be very powerful in the ſcurvy.

Metals combined with theſe ſubſtances are called *metals mineraliſed by ſulphur*, or *by arſenic*, or *by ſulphur and arſenic*; and theſe matters are called *mineraliſing* ſubſtances.

Beſides the ſulphur and arſenic with which metals are ſtrictly combined in the mineral ſtate, they are alſo pretty intimately combined with earthy ſubſtances, of different natures, and more or leſs divided. A part of this earth is diſpoſed to metalliſation, and is convertible into a metal by combination with phlogiſton. It is called *metallic earth*, and probably proceeds from a portion of metal which has been decompoſed, and deſtroyed in its ore by different cauſes, which we ſhall mention afterwards. Perhaps alſo this earth may be only a ſimple earth naturally diſpoſed to metalliſation, or the firſt beginning of a metal which nature has not yet brought completely to a metallic ſtate.

We are to obſerve upon the ſubject of this metallic earth, that it is found not only amongſt mineraliſed metals, but that it appears diffuſed, although in very ſmall quantity, in large maſſes of ordinary earth which is found every where, ſuch as ſands, clays, and mud. Mr. Cramer thinks that the experiments mentioned by Becher in his third Supplement to his *Phyſica Subterranea*, by which he extracts gold or iron from any ſands or clays, are demonſtrative upon this ſubject. The other portion of earth which is intimately mixed with mineraliſed metals, cannot be reduced into metals, and is therefore called *unmetallic earth*. This is an ordinary earth.

Theſe different matters united together form maſſes which are compact, heavy, brittle, and frequently poſſeſſed of much metallic luſtre. Theſe ſubſtances are properly called *ores*, or the matter of mines.

Theſe ores are found in earths and ſtones of different kinds, as ſands, flints, cryſtals, ſlates, indurated clays, according to the ground in which they are contained. But two kinds of ſtones in particular ſeem to accompany ores, and have therefore been conſidered by ſeveral mineralogiſts as matrixes, in which metals are formed. One of theſe ſtones is a kind of cryſtal, generally white, milky, and ſemi-opake, ſtriking fire with ſteel, and of the claſs of vitrifiable earths. It is called *quartz*. *See* QUARTZ.

The other ſtone is leſs hard, which does not ſtrike fire with ſteel, and is ſometimes milky like quartz; ſometimes tranſparent and diverſely colored, conſiſting of rhomboidal cryſtals, which are compoſed of plates and faces. This ſtone becomes more ſoft and friable by being expoſed to fire. It is called *ſpar*. Spar is more like to gypſeous ſtones than to any other, but it differs from gypſeous ſtones in poſſeſſing a much greater denſity. Some ſpars are ſo heavy, that they exceed in this reſpect all other ſtones. *See* SPAR.

Theſe earthy and ſtoney ſubſtances ought to be well diſtinguiſhed from the earth intimately mixed with the ore, as is mentioned above; this latter earth conſtituting part of the ore, whereas the others are only accidental, and externally adherent. They form the *matrix of the ore*.

Mines have generally the form of veins, or of congealed currents, which have different directions, and which are diſtributed in branches. The mines take different appellations according to the direction of their veins.

The *deep mines* are thoſe which deſcend from the ſurface of the earth, either vertically, or more or leſs obliquely towards its center.

Thoſe

Those which are extended horizontally are called *dilated mines*, because they frequently are considerably broad.

Some mines compose masses more or less extensive, and almost equally long, broad, and thick. These latter are called *accumulated mines*.

Some authors have said that the veins of mines are always directed from east to west, from north to south, or in the intermediate directions, according to the nature of the metals. But this opinion is not well supported by facts; for we are certain that veins of every metal run in every direction. The direction of mines is determined by their descent, like that of rivers, and by help of a mariner's compass.

From several signs we may know that a field or a mountain contains a mine, particularly when the mine is near the surface of the earth. For, from grounds filled with minerals, sulphureous and metallic vapors rise, which are sometimes so considerable as to affect the senses, but which most frequently only shew themselves by the effects which they produce on plants, which they render weakly, and discolored. Frequently even, mineralogists say, these places are entirely barren, and no vegetables grow there, although the ground seems to be of a good quality, and fit for vegetation.

The sources of mineral waters; the nature of the stones upon the ground being that of quartz or spar; bits of minerals lying on the ground; are so many proofs of the presence of mines.

But we must not altogether depend on these signs; for notwithstanding them, we often find no mines, or very poor ones, when we dig the ground.

The digging of the ground is then the only certain method of determining the existence of a mine, and of what kind it is; for the *wand of divination*, by which many pretend that mines and their quality may be discovered, is a chimera, which owes its reputation to credulity and ignorance.

Metallic minerals are divided into two classes. The first includes all those, in which the quantity of metal exceeds the quantity of sulphur, arsenic, and unmetallic earth; or from which metal may be advantageously extracted. These minerals are particularly called *ores*.

In the second class are placed all minerals which contain more sulphur, arsenic, and unmetallic earth than metal; and these in general are called *pyrites*.

Pyrites and ores are of the same nature, and are often both found in the same places. But as the proportion of the principles of these compounds is different, their properties also differ. We shall explain the properties of pyrites under the article *pyrites*, and the properties of ores in this present article.

Ores may be considered in two ways; first, as containing useful and valuable substances, and they then receive their name from the most valuable metal which is obtained from them. Thus, for instance, as silver is much more valuable than lead, a mineral, a quintal of which contains a mark of silver, and sixty pounds of lead, or more, is called *an ore of silver*, because the mark of silver is more valuable than the 60 pounds of lead. This manner of denominating ores is chiefly used by the miners.

In the second place, we may chiefly attend to the metal the largest quantity of which is contained in a mineral, without attending to its value, and affix its name to the ore. In this manner, the ore just now mentioned would be called

called *an ore of lead,* and not *an ore of silver.* But the best method seems to be, to call such an ore *an ore of lead containing silver,* as is very frequently done.

Mr. Cramer, a profound and judicious chemist, who has particularly attended to this subject, thinks that we ought to call an ore, the *proper ore of that metal* which it contains in largest quantity, and to call it the *improper ore* of all the other metals it may contain. This method of distinguishing ores is certainly one of the best and most exact. We shall now give a summary description of the principal kinds of ores of each metallic substance. *(b).*

(*b*) As metallurgy is the most important part of chemistry, we hope that a *sketch of the History of Mines*, and a more particular *enumeration of ores* than is contained in the text, together with a relation of the most approved methods of extracting metals from ores, for the purposes of *essay*, or of *commerce* and *manufacture*, may be not unacceptable. In the present Note, we shall treat of mines, and of ores in general: Under the articles in the text, which treat of the ores of the several metals, we shall subjoin an enumeration of those which are there omitted, and also the methods of essaying the several ores to discover the quantities and qualities of their contents: Lastly, under the article, SMELTING *of* ORES, we shall make some additions concerning the methods of extracting metals from large quantities of ores for the purposes of commerce and manufacture.

Concerning ORES *and* MINES.

ORES consist, 1. Of metallic substances *calcined*; or, 2. Of these substances combined with other matters, with which they are said to be *mineralised.*

Calcined metallic substances, or *calciform ores*, are metallic substances deprived of phlogiston, and in the state of a calx, or metallic earth. *See* CALX. Such are all *ferruginous ochres*, which are calxes of iron.

Mineralised ores are, 1. *Simple*, containing only one metallic substance: or, 2. *Compound*, containing two or more metallic substances.

Of the simple, and also of the compound ores, four kinds may be distinguished.

1. Ores consisting of metallic substances mineralised by *sulphur*. Such is the lead-ore called *galena*, composed of lead and sulphur.

2. Ores consisting of metallic substances mineralised by *arsenic*. Such is the *white pyrites*, containing iron and arsenic.

3. Ores consisting of metallic substances mineralised *by sulphur and by arsenic*. Such is the *red silver-ore*, containing silver, arsenic, and sulphur.

4. Ores consisting of metallic substances mineralised by *saline matters*. Such are the *native vitriols*. Such also is probably the *corneous silver-ore*, which, according to Mr. Cronstedt's opinion, is a luna cornea, or silver combined with marine acid. Of this kind of ores, or native metallic salts, is perhaps the *sedative salt of borax*, which appears, from Mr. Cadet's experiments, published in the Memoirs of the Royal Academy for the year 1766, to be copper combined with marine acid, and which has been said to be found native. To this class also may be referred the *silver mineralised by an alkaline substance*, which Mr. Von Justi pretends to have discovered.

Henckel, and after him Cramer, and the author of the Dictionary of Chemistry, pretend that in mineralised ores, besides the above-mentioned metallic and mineralising substances, are also contained a metallic and an unmetallic earth. But Wallerius affirms, that the existence of such earths cannot be shewn, and that sulphur is incapable of dissolving unmetallic earths, and even the calxes of all metallic substances, excepting those of lead, bismuth, and nickel.

Having thus defined and distinguished the several general classes of ores, we proceed to shew how they are lodged, and where they are found.

Metals and *metalliferous ores are found* in various places. I. They are found *under water*; in beds of rivers, lakes and seas, and chiefly at the flexures of these: Such are the

♂

DX. ORES *of* GOLD. In taking the word *ore* in the sense above-mentioned, no ores of gold exist: for as this metal cannot be allayed

the auriferous and ferruginous sands, grains of native gold, ochres, and fragments of ores washed from mines.

II. They are found *dissolved in water*: Such are the vitriolic waters containing iron, copper, or zinc.

III. They are found *upon the surface of the earth*. Such are many ochres; metalliferous stones, sands, and clays; and lumps of ores. Mr. Gmelin says, that in the northern parts of Asia, ores are almost always found upon or near the surface of the ground.

IV. They are found *under the surface of the earth*. When the quantity of these collected in one place is considerable, it is called a *mine*.

Subterranean metals and ores are differently disposed in different places.

1. Some are *infixed in stones and earths*, forming *nodules* or *spots* diversely colored.

2. Some are equably and *uniformly diffused through the substance of earths and stones*, to which they give color, density, and other properties. Such are the greatest part of those earths, stones, sands, clays, crystals, flints, gems, and fluors, which are colored.

3. Some form *strata* in mountains. Such are the slates containing pyrites, copper-ore, lead-ore, silver-ore, or blend. These lie in the same direction as the strata of stones betwixt which they are placed, but they differ from the ordinary strata in this circumstance, that the thickness of different parts of the same metalliferous stratum is often very various; whereas the thickness of the stoney strata is known to be generally very uniform.

4. *Fragments of ores* are frequently found accumulated in certain subterranean cavities, in fissures of mountains, or interposed betwixt the strata of the earth. These are loose, unconnected, frequently involved in clay, and not accreted to the contiguous rocks or strata immediately, nor by intervention of spar or of quartz, as the ores found in veins are. Tin and iron mines are frequently of the kind here described.

5. Large entire masses of ores are sometimes found in the stoney strata of mountains. These are improperly called *cumulated veins*, because their length relatively to their breadth and depth, is not considerable.

6. Some instances are mentioned of *entire mountains* consisting of ore. Such is the mountain Taberg in Smoland; and such are the mountains of Kerunavara and Luosavara in Lapland, the former of which is 1400 perches long, and 100 perches broad. These mountains consist of iron-ore.

9. Lastly, and chiefly, metals and ores are found in oblong tracts, forming masses called *veins*, which lie in the stoney strata composing mountains.

The direction of veins greatly varies; some being straight, and others curved. Their position also respecting the horizon is very various; some being perpendicular, some horizontal, and the rest being of the intermediate degrees of declivity.

The dimensions, the quality, and the quantity of contents, and many other circumstances of veins, are also very various. Miners distinguish the several kinds of veins by names expressive of their differences. Thus veins are said to be *deep*; *perpendicular*; *horizontal*, or *hanging*, or *dilated*; *rich*; *poor*; *morning*, *noon*, *evening*, and *night* veins, by which their direction towards that point of the compass where the sun is at any of these divisions of the natural day, is signified.

The stratum of earth or stone lying above a vein is called its *roof*: and the stratum under the vein is called its *floor*.

Some parts of veins are considerably thicker than others. Small veins frequently branch out from large veins, and sometimes these branches return into the trunk from which they issued. These veins, from which many smaller veins depart, have been observed to be generally rich.

Veins are terminated variously; 1. By a gradual diminution, as if they had been compressed, while yet soft, by superincumbent weight; or by splitting and dividing into several smaller veins: or, 2. They are terminated abruptly, together with their proper strata in which they lie. This abrupt termination of veins and strata is occasioned by their being crossed by new strata running transversely to the direction of the former; or by perpendicular fissures through the strata; which fissures are frequently

with arsenic, nor with sulphur, it is never found directly mineralised by these substances, as the other metals are. In the second place, if it be mineralised

quently filled with alluvial matters, or with water, or are empty. These perpendicular fissures seem to have been occasioned by some rupture or derangement of the stratum through which the vein passes, by which one part of it has been raised or depressed, or removed aside from the other, probably by earthquakes. Where the vein is terminated abruptly, it does not cease, but is only broken and disjoined; and is often recovered by searching in the analogous parts of the opposite side of the deranged stratum. A principal part of the art of miners consists in discovering the modes of these derangements from external marks, that they may know where to search for the disjoined vein.

The *contents of veins* are metals and metalliferous minerals, as, the several kinds of ores, pyrites, blends, guhrs, vitriols; the several kinds of fluors, spars, quartz, hornblend, in which the ores are generally imbedded, or inveloped, and to which therefore the name, *matrix of the ore*, is applied; stalactites; crystallizations of these metalliferous and stoney substances encrusting the small cavities of the circumjacent rock; and lastly, water, which flows or drops through crevices in that rock.

In a vein, ores are found sometimes attached to the rock or stratum through which the vein runs, but more frequently to a matrix which adheres to the rock; and sometimes both these kinds of adhesion occur in the same vein at different places. Frequently betwixt the matrix and the rock is interposed a thin crust of stone or of earth, called by authors the *fimbria of the ore*.

The *matrix* or the stone in which the ore lies inveloped is of various kinds in different veins. And some kinds of stone seem better adapted than others to give reception to any ore, or to the ores of particular metals. Thus quartz, spar, fluors, and hornblend give reception to all ores and metals; but slates, chiefly to copper and silver, and never to tin; calcareous and sparry matrixes, to lead, silver, and tin; and mica to iron.

Veins lie in strata of different kinds of stone; but more frequently in some kinds of stone than in others. s of the simple or uncompounded stones which compose strata, the following are metalliferous: *calcareous stones*; *slaty sand-stone* (cos fissilis arenosus Wallerii); *feltspar* (spatum pyrimachum sive scintillans); *quartz*; sometimes *jasper*; frequently *slates*; and chiefly *micaceous* or *talky* stones; and *hornblend* (lapis corneus Wallerii; bolus indurata particulis squamosis Cronstedt). No veins have been found in gypseous or in siliceous strata, altho' *chertz* and *flints* frequently contain metallic particles, and some instances have been observed of ores of silver and of tin in *alabaster*. Of compound stones, those are said to be chiefly metalliferous which consist of particles of hornblend. Veins have also been found in the *red granite*; but seldom, if ever, in any other *granite*, or in *porphyry*. In general, veins are more frequently found in soft, fissile, and friable strata, than in those which are compact and hard.

A vein sometimes passes from one stratum into the inferior contiguous stratum. Sometimes even the veins of one stratum do so correspond with those of an inferior stratum, the contiguity of which with the former is interrupted by a mass of different matter through which the veins do not pass, that they seem originally to have been continued from one stratum to the other. Thus in the mines of Derbyshire, where the veins lie in strata of limestone, the contiguity of which strata with each other is interrupted in some places by a blue marle or clay, and in other places by a compound stone called *toadstone*; the veins of one stratum frequently correspond with the veins of the inferior stratum of limestone, but are never continued through the interposed clay or toadstone. But we must observe, that these interposed masses, the blue marle, clay, and toadstone, have not the uniform thickness observable in regular strata, but are (especially the toadstone) in some places a few feet in depth, and in others some hundreds of yards. The above disposition seems to indicate, that these several strata of limestone have been originally contiguous; that the veins now disjoined have been once continued; that these strata of limestone have been afterwards separated by some violent cause, probably by the same earthquakes which have in a singular manner

indirectly by the union it contracts with other metals naturally combined with sulphur and arsenic, so small a quantity of it only is found in these ores, that they scarcely even deserve the name of *improper ores of gold*.

ner shattered the strata of this mountainous country; that the interstices thus formed between the separated strata have been filled up with such matters as the waters could insinuate, probably with the mixed comminuted ruins of shattered strata; and, lastly, that these shattered strata have consisted of argillaceous and of calcareous earths, as appears from the clay; from the marle, which is a mixture of clay and calcareous earth; and from the toadstone, which consists of particles of hornblend (which Mr. Cronstedt justly considers as an indurated bole or clay) mixed with particles of calcareous earth.

To the above historical sketch of mines we shall add some conjectural remarks concerning their *formation*.

Those ores which are found under water (I.); upon the surface of the earth (III.); in fissures of mountains and subterranean cavities, accumulated, but not accreted to the contiguous rocks, (IV. 4.) seem from their loose, unconnected, broken appearance, to have been conveyed by alluvion.

All martial ochres have probably been separated from vitriolic ferruginous waters (II.) either spontaneously or by calcareous earth; and these waters seem to have acquired their metallic contents by dissolving the vitriol which is produced by the spontaneous decomposition of martial pyrites. The ochres of copper, zinc, and perhaps of several other metals, have probably been precipitated from vitriolic waters by some substance, as calcareous earth, more disposed to combine with acids; and these vitriolic waters have probably been rendered metalliferous, by dissolving the vitriols produced by a combustion of cupreous pyrites, and of blend; for these minerals are not, as martial pyrites is, susceptible of decomposition, spontaneously, or by air and moisture.

The metalliferous nodules and spots (IV. 1.) seem to have been infixed in stones while these were yet soft. Perhaps the metalliferous and lapideous particles were at once dissolved and suspended in the same aqueous menstruum, and during their concretion, crystallized distinctly, as different salts do, when dissolved in the same fluid.

The earths and stones uniformly colored by metals (IV. 2.) were also probably in a soft state while they received these tinges. The opake-colored stones seem to have received their color from metallic calxes mixed and diffused through the soft lapideous substance; and the transparent-colored stones have probably received their colors from vitriolic salts, or from metallic particles dissolved in the same water which softened or liquefied the stony substance; which metallic salts and particles were so much diffused, that they could not be distinctly crystallized. That all stones have been once liquid and dissolved in water, appears probable not only from their regular crystallized forms, but also from the solubility of some stones, as of gypseous and calcareous earths, in water; and from the water which we know is contained in the hardest marbles, as well as in alabasters; to which water these stones owe the crystallization of their particles.

The veins called *cumulated*, (IV. 5.) and the entirely metalliferous mountains (IV. 6.) are believed by Wallerius to be analogous to the nodules (IV. 1.). These metalliferous substances seem to have been originally formed or concreted in the places where they are found.

The metalliferous strata (IV. 3.) have probably been insinuated between the lapideous strata, after the separation of these from each other by some violent cause; in the same manner in which we supposed that the clay and toadstone have been insinuated betwixt the several strata of limestone in Derbyshire. The matters thus insinuated may have been either fluid, which would afterwards crystallize, and form entire regular masses; or they may have been the ruins of shattered strata and veins brought by waters, and there deposited; in which case they will appear broken and irregular. These metalliferous strata, although frequently confounded with the horizontal or dilated veins, may be distinguished, according to Wallerius, from these by the following properties: 1. They are generally thinner and much broader than the veins called dilated. 2. They are seldom found at a greater depth than a hundred perches, and generally in the neighbourhood of

Hence gold is found either in its natural ſtate, of a certain degree of purity, poſſeſſed of all its properties, or engaged with ſome other metals in certain minerals.

of veins, from which they probably have received their contents. 3. From their want of the thin encruſtations called *fimbriæ*, which, we obſerved, are frequently interpoſed betwixt the rock and the ore or its matrix; and from their want of the other properties of veins.

But in *veins*, properly ſo called, the ſtrongeſt marks exiſt of ores having been there concreted, and not depoſited in their preſent ſtate. Their regular, unbroken appearance, their accretion to the contiguous rock, either immediately or by intervention of a matrix, the regular appearance of this matrix inveloping the ore, the frequent cryſtallization of the ore and of the other contents of the vein, indicate, that ores, as well as the other ſolid contents, have been there concreted from a fluid to a ſolid ſtate.

Moſt authors believe, that veins, and the perpendicular clefts in the ſtony ſtrata of mountains, called *Fiſſures*, have been produced by the ſame cauſe; or rather, they conſider veins only as fiſſures filled with metalliferous matters. They further believe, that fiſſures have been occaſioned by the exſiccation of ſtrata, while theſe were paſſing from a fluid to a ſolid ſtate. Wallerius thinks, that fiſſures have been formed from exſiccation, but that veins were channels made through the ſtrata, while yet ſoft and fluid, by water, or by the more fluid parts of the ſtrata penetrating and forcing a paſſage through the more ſolid parts. He thinks, that theſe fluid parts conveyed thither their metalliferous and ſtony contents, which were there coagulated or concreted. He ſupports his opinion by obſerving, that all the veins of the ſame ſtratum generally run parallel to each other; that they frequently bend in their courſe; that the ſame vein is ſometimes contracted and ſometimes dilated; that veins are frequently terminated by being ſplit or divided into inferior veins; that veins are frequently wider at bottom than at top, whereas fiſſures are always wideſt at top and are very narrow below: all which appearances, he thinks, could not have been produced by exſiccation. From theſe reaſons, fiſſures appear to have had a different, and from the disjunction and rupture of veins croſſed by fiſſures, they ſeem to have had a later origin than veins. Whether fiſſures could have been produced by the very gradual exſiccation of theſe large maſſes of ſtrongly coherent matter; or whether they have been produced by the ſame violent cauſes, namely, earthquakes, by which the ſtrata in which fiſſures are generally found have been broken and deranged, and by which metalliferous mountains themſelves have been formed, or their ſtrata raiſed above their original level; as ſome authors have, with great probability, conjectured; I do not pretend to determine.

Veins are ſeldom, if ever, found but in mountains. The reaſon of which may not improbably be, that in metalliferous mountains we have acceſs to the more ancient ſtrata of the earth, which in plains are covered with ſo many depoſited, alluvial, and other later ſtrata, that we can ſeldom, if ever, reach the former. That theſe mountains conſiſt of ſtrata which have been originally lower than the upper ſtrata of adjacent plains, appears from an obſervation which has been made, that the ſtrata of mountainous countries dip with more or leſs declivity as they approach the plains, till they gradually ſink under the ſeveral ſtrata of thoſe plains, and are at laſt immerſed beyond the reach of miners. This leading fact in the natural hiſtory of the earth has been obſerved by a ſagacious philoſopher, *Mr. Mitchell*, in his *Conjectures concerning Earthquakes, &c. Philoſ. Tranſ.* 1760.

That the inferior ſtrata of the earth contain large quantities of pyritous, ſulphureous, and metalliferous matters, appears, 1. From the ſubterranean fires in thoſe inferior ſtrata, which produce volcanos, and probably earthquakes (as Mr. Mitchell ingeniouſly conjectures). 2. From the obſervation, that all kinds of mountains are not equally metalliferous; but that veins, eſpecially, are only found in thoſe mountains, which, being compoſed of very ancient ſtrata, are called *primæval*, which form the chains and extenſive ridges on the ſurface of the earth, which direct the courſe of the waters, and which conſiſt of certain ſtrata, the

The gold which is found alone is called *native* or *virgin gold*. This is generally incrusted, and fixed in different kinds of stones, principally in flints

the thickness of each of which, its generic qualities, and its position relatively to the other strata, are, in different parts of the chain of mountains where that stratum is found, nearly uniform and alike, notwithstanding that the numbers, and the inclinations of the strata composing contiguous mountains, or even different parts of the same mountain, are often very various; and therefore that veins are seldom, if ever, found in the mountains called by authors *diluvial* and *temporary*, which are single, or detached, which consist, not of strata uniformly disposed, but of alluvial masses, in which fragments of ores may be sometimes, but veins never, found. Nevertheless, single, and seemingly detached, mountains in small islands have sometimes been found to be metalliferous. But we must observe, that these mountains consist of uniform strata; that islands themselves, especially small islands, may be considered as eminent parts of submarine ranges of mountains; and that the mountains of such islands may be considered as apices or tops only of inferior mountains.

Those mountains are said to be most metalliferous which have a gentle ascent, a moderate height, and a broad basis, the strata of which are nearly horizontal, and not much broken and disjoined. In these mountains, at least, the veins are less interrupted, more extended, and consequently more valuble to miners than the veins in lofty, craggy, irregular, and shattered mountains.

Authors dispute concerning the time in which ores have been formed, some referring it to the creation of the world, or to the first subsequent ages; and others believing, that they have been gradually from all times, and are now daily, formed. From the accretion of ores and of their matrices to their proper rocks, and from the insertion of metalliferous nodules and striæ in the hardest stones, we are inclined to believe, that the matter of these veins and nodules are coeval with the rocks and stones in which they are inveloped. Nevertheless, we cannot doubt that small quantities, at least, of ores are still daily formed in veins, fissures, and other subterranean cavities. Several well attested instances confirming this opinion are adduced by authors: Cronstedt mentions an incrustation of silver-ore that was found adhering to a thin coat of lamp-black, or of soot, with which the smoke of a torch had soiled a rock in a mine at Koningsberg in Norway; and that this incrustation of silver-ore had been formed by a metalliferous water passing over the rock. Lehman affirms, that he possesses some silver-ore attached to the step of a ladder, found in a mine in Hartz, which had been abandoned two hundred years ago; and that several steps of ladders similarly encrusted had been found. Many other instances are mentioned by authors, of galena, pyrites, silver-ores, and other metalliferous substances, having been found adhering to wood, to fossil-coal, to stalactitical encrustations, to oyster-shells, and other recent substances. From these, and from similar instances which I have seen, I am induced to believe, that not only ochres and fragments of ores may, with other alluvial matters, be now daily deposited, but also that small quantities of mineralised ores are recently formed; although many histories mentioned by Becher, Barba, Henckel, and other authors, of the entire renovation of exhausted veins, and especially those of the growth and vegetation of metals and of ores, appear to be at least doubtful.

Various opinions have been published concerning the formation of mineralised ores. According to some, these ores were formed by congelation of the fluid masses found in mines, called *Guhrs*. *See* GUHR. Other authors believe, that ores have been formed by the condensation of certain mineral, metallic, sulphureous, and arsenical vapors, with which they suppose that mines abound. Some have even affirmed, that they have seen this vapor condense, and become in a few days changed into gold, silver, and other metallic matters: but the existence of such vapors is not ascertained; for the noxious vapors commonly supposed to be sulphureous, arsenical, and metalline, are nothing but the permanently elastic vapors called *inflammable* and *uninflammable fixable airs*. *See* DAMPS.

Whether the component parts of ores have been once reduced to a state of vapor, and

and quartz. Mr. Cramer ſays, that the yellow brilliant ſpots of the blue ſtone, called *lapis lazuli*, are native gold; but theſe are very ſmall. (*c*)

Gold is alſo found in fat and muddy earths; and Mr. Cramer affirms, that ſcarcely any ſand can be found which does not contain gold; but he acknowledges, at the ſame time, that the quantity is too ſmall to compenſate for the expence of obtaining it.

Laſtly, the largeſt quantity of native gold is to be found in the ſands of ſome rivers. It is chiefly collected in hollows at the bottom of theſe rivers, and at their ſeveral bendings. The gold is collected in theſe places by a natural operation, ſimilar to that of waſhing of ores.

A conſiderable quantity of gold is in the ſand of ſeveral rivers in France; ſo that perſons who collect it find enough to compenſate their trouble. Mr. Reaumur, in a Memoir that he gave in the year 1718 concerning the Rivers of France which contain gold, enumerates ten of them, namely, the Rhine, the Rhone, the Doux, the Ceze, and the Gardon, the Arriege, the Garonne, two ſtreams which flow into the Arriege, called Ferriet and Benagues; laſtly, the Salat, the ſource of which is in the Pyrenean mountains.

The Ceze is the river which furniſhes the largeſt quantity of gold at certain times. Mr. Reaumur obſerves, that its particles are larger than thoſe of the Rhine and of the Rhone, and ſays, that in ſome days a peaſant will find gold to the value of a piſtole, and in others will ſcarcely find any.

and in that ſtate have been united; or whether theſe parts were conveyed to veins already combined, but in a fluid ſtate; or by what natural proceſs they have been brought together and united, we have not ſufficient data to inveſtigate and determine.

We can indeed by analyſis diſcover what theſe component parts of ores are; and we can even imitate many ores by fuſing together thoſe parts: but, from the regularity of the forms and ſtructures of ores, the union of their component parts muſt have been accompliſhed by a more gradual proceſs; and, although it be difficult to explain how ores could be diſſolved in a watery menſtruum, and afterwards cryſtallized, ſo as to form the regular maſſes which they now conſtitute; yet when we conſider how many ſolutions and decompoſitions are effected by the very ſlow and gradual operations of nature, which cannot be effected by thoſe of art, the conjecture (if, in a ſubject ſo obſcure, and concerning which neither ſufficient facts have been diſcovered, nor is the life of man ſufficiently long to make obſervations and experiments, conjectures may be admitted) ſeems not improbable that ores, and perhaps all other mineral cryſtallized matters, as ſpars, cryſtals, fluors, &c. have been once diſſolved in an aqueous menſtruum, by evaporation of which they have been afterwards concreted and cryſtallized. An inſtance of the formation of ſilver-ore from a metalliferous water has already been quoted from a Memoir in the Swed. Act. by Mr. Cronſtedt. The liquors called *guhrs*, found in mines, are known to contain frequently, beſides metallic matters, alſo calcareous and gypſeous particles. By intervention of theſe earthy matters, may not alſo ſulphur be diſſolved in water, and thus a hepar, the moſt powerful ſolvent of metallic ſubſtances, be formed? If we ſuppoſe ſuch a hepar impregnated with metallic particles to be collected in a ſubterranean cavity, where the water might be exceedingly ſlowly evaporated, till no more remained than was ſufficient for the cryſtallization of the ſolid matters, might not theſe matters then ſeparate and cryſtallize diſtinctly; the earthy ſubſtances firſt concreting, and forming ſpars, fluors, and other matrixes, which would adhere to the ſolid rock, while the ſulphureous, arſenical, and metallic ſubſtances ſhould afterwards concrete together, and compoſe ores which would adhere to the matrixes previouſly formed?

(*c*) Concerning theſe, *ſee* LAPIS LAZULI.

The native gold found in rivers or elsewhere is never perfectly pure, or of twenty-four karats. It always contains a certain quantity of allay, which is generally silver. The gold of our rivers, according to Mr. Reaumur's trials, was found to be from eighteen to twenty-two karats, that of the Ceze being the lowest, and that of the Arriege being the purest. (*d*).

DXI. ORES *of* PLATINA. Platina is very rare, and has been but lately discovered. As, like gold, it cannot be allayed with sulphur or with arsenic, probably no ore properly so called exists of this metal. Accordingly,

(*d*) ORES *of* GOLD. Although gold cannot be directly dissolved by sulphur, yet it probably may be mineralised by the intervention of other metallic matters. Thus, although no proper ore of gold exists, yet it is found in several mineral substances, in which it is always accompanied, as Cramer affirms, with a much larger quantity of silver; to which latter metal that author attributes its mineralised state. The minerals containing gold are blend, cupreous and arsenical pyrites, ore of antimony, cinnabar, white ore of arsenic, vitreous and other silver ores, and the lead-ore called galena.

Gold is more frequently imbedded in quartz than in any other matrix, but it is also found in limestone and in hornblend. Gold mines are in general very precarious, as they do not form regular veins, nor is the gold uniformly distributed through a matrix.

Becher and Cramer think, that no sand is entirely free from gold. The yellow, red, black, and violet-colored ferruginous, are said to contain most gold. Mr. Hellot relates, that in eleven essays of one kind of sand, from a quintal, or 921600 grains, were obtained each time from 848 to 844 grains of noble metal, exclusive of the gold which remained in the scoria; and that of the metal thus obtained two thirds were gold, and the remaining third was silver. He says, that parcels of sand taken up at very small distances from each other contained very unequal proportions of gold.

The gold found in sands is generally less pure than that which is imbedded in a solid matrix. Reaumur says, that a piece of gold, weighing 448 ounces, was shewn to the Royal Academy at Paris, which was found upon essay to have different fineness in different parts of the mass.

Ores and earths containing gold may be essayed by the methods directed for the extraction of gold from large quantities of these auriferous matters (*see* SMELTING *of* ORES): or they may in general be essayed by being fused in a cupel or test, placed under the muffle of an essay-furnace, or in a crucible placed in an air-furnace, with eight or ten times their quantity of lead, if they be fusible; and with a larger quantity of lead, if they be difficultly fusible; and by scorifying the earthy matters, while the lead becomes impregnated with the noble metals. These operations are entirely similar to those employed for the separation of silver from its ores by precipitation with lead; *a detail of which see subjoined under the article* ORES *of* SILVER, *in a Note* [*Processes* I. III. IV. V. VI]. These metals are afterwards to be separated from the lead by cupellation, in the manner directed in the articles, ESSAYS *of the* VALUE *of* SILVER, *and of* GOLD. The gold is then to be separated from the silver by the processes described in the article PARTING.

The quantity of lead to be added to the ore in this essay must be such as renders the scoria very thin, that the whole gold may be imbibed by the lead. Some iron-ores containing gold cannot be reduced into a scoria sufficiently thin with sixteen times their quantity of lead, unless the heat be, at the same time, considerably encreased. When the ore is exceedingly refractory, the scorification ought to be promoted by adding to it four times its quantity of tartar, twice its quantity of nitre, and four times its quantity of litharge. This mixture is to be put in a good essay-crucible, and covered with sea-salt. The crucible is to be set in a forge-hearth, and exposed gradually to heat, till the scoria has acquired sufficient fluidity, and the lead has imbibed the noble metal.

See the methods which have been used for essaying auriferous sands, under the article SMELTING *of* ORES.

in

in the only mines of platina which we know, namely, the gold mines of Santafe near Carthagena, the platina is found native like the gold, and in its metallic ſtate.

DXII. ORES *of* SILVER. Next to gold, ſilver is the metal moſt frequently found in its metallic ſtate, that is, not mineraliſed by ſulphur or by arſenic. This ſilver, called alſo *native* or *virgin*, generally affects ſome regular form, and conſiſts of filaments or vegetations of various figures. Native ſilver, like gold, is incruſted, or adherent to ſeveral kinds of ſtones. It is generally allayed with ſome gold: but ſilver, like all the other metals, is much more frequently found mineraliſed by ſulphur and by arſenic. (*e*)

Three principal proper ores of ſilver are known, which are very rich, but vere rare. Theſe are;

1. The *vitreous ſilver ore.* This ore has no determinate figure, and has nearly the color, ſoftneſs, and fuſibility of lead. It is very heavy, and contains three quarters of its weight of pure ſilver. In this ore the ſilver is mineraliſed by ſulphur alone. Some expert artiſts imitate it very well by combining ſulphur with ſilver by fuſion in a crucible. (*f*)

2. The *horny* or *corneous ſilver ore.* This ore is ſo called from its color and ſemitranſparency, by which it reſembles horn or colophony. This ore, being ſuddenly heated, crackles, as almoſt all ores do, and melts with a gentle heat. Two-thirds of it are ſilver, which is mineraliſed by ſulphur and arſenic. This ore is very rare. Wallerius ſays, after Woodward, that it is found at *Johaun-Georgen-Stadt* in *Saxony.* (*g*)

3. *Red ſilver ore*, called alſo *Roſiclare.* Its color is more or leſs red; it is ſometimes cryſtallized, very heavy, and is fuſible like the above-mentioned ores. In this ore the ſilver is mineraliſed by arſenic and by ſulphur, but chiefly by the former. It alſo contains a little iron, and furniſhes two-thirds of its weight of ſilver. Its red color may proceed either from the iron it contains, or from the mixture of arſenic and ſulphur, or, laſtly, from the particular manner in which the arſenic is united with the ſilver, an example of which we have

(*e*) ORES *of* SILVER. *Native ſilver* is found in form of plates, of fibres, or of grains, or cryſtallized. It lies generally in quartz, flint, ſpar, ſlate, cobalt, and in ſilver-ores. It is ſometimes enveloped in a thin ſtony cruſt.

(*f*) The *vitreous ore*, according to Cronſtedt, is either in form of plates or of fibres, or is cryſtallized, or has no determinate figure. It may be imitated by adding about five parts of ſulphur to one part of melted ſilver; in which operation moſt of the ſulphur is conſumed: or it may be imitated by expoſing a plate of ſilver red-hot to the fumes of burning ſulphur.

(*g*) *Corneous ore* has various colors; white, pearly, brown, yellow, greeniſh, or reddiſh. It is foliated and ſemitranſparent. It is ſomewhat ductile, and fuſible with the flame of a candle. When heated, it emits, as Wallerius ſays, a ſulphureous and blue flame, and, according to Cramer, alſo a very ſmall quantity of an arſenical fume. Wallerius ſays, that it contains two-thirds of ſilver, with a conſiderable quantity of ſulphur and a ſmall quantity of arſenic. Lehman thinks, that it is ſilver united with a little arſenic. But Mr. Cronſtedt ſays, that it is a luna cornea, or ſilver combined with marine acid; and that it is incapable of being decompoſed but by ſubſtances which can unite with that acid. This latter opinion ſeems to be the moſt probable, as the ore, according to its deſcription, is ſimilar to luna cornea, and as it cannot be imitated by any mixture of ſulphur and of arſenic with ſilver. The blue flame, and the ſmell ſlightly arſenical, which are emitted from heated corneous ore, are alſo obſervable from every combination of marine acid with a ſubſtance containing phlogiſton.

have in the red precipitate of silver made by the neutral arsenical salt. *See* ARSENIC *and* SALT (NEUTRAL ARSENICAL). (*b*)

Besides these, many other minerals are called silver ores, but which are only improper ores of silver as they contain a larger quantity of some other metal (*i*).

(*b*) *Red silver ore* is either plated or solid, or crystallized, and frequently semitransparent. Its color is various, from a dark grey to a deep red, according to the proportions of the two mineralising substances. It crackles and breaks in the fire, exhales an arsenical fume, and is readily fused. It is found generally in quartz, spar, crystal, hornblend.

(*i*) Besides the three silver-ores above described, the following ores contain silver mixed with other metals.

1. *Grey silver ore.* This contains copper and silver mineralised by arsenic and sulphur, and generally more of the former than of the latter metal; but as it is valued chiefly for the silver, it has been generally enumerated amongst silver ores.

2. *White silver ore* is an arsenical pyrites containing silver.

3. *Black silver ore* contains sulphur, arsenic, copper, iron, sometimes lead, and about a fourth part of silver, according to Wallerius.

4. *Plumose silver ore* is white or black, striated like plume-alum, or like ore of antimony. It is silver mineralised by sulphur, arsenic, and antimony.

5. *Pech-blend.* In this blend silver, gold, and zinc, are mineralised by sulphur, probably by intervention of iron, by which the gold and zinc are rendered capable of uniting with the sulphur.

6. Silver is frequently found in *galena*; and sometimes in *martial pyrites*; in the *red ore of arsenic*; in various *ores of copper*, *lead*, *tin*, *iron*, and especially *cobalt*; in *blends*; in *yellow* or *red earths*; in *black* and *blue basaltes*; and also in *strata of stones*, which do not appear externally to contain any mineral substance.

7. *Liquid silver ore*, or *guhr of silver*, is a grey or whitish liquid mass which contains, as Wallerius says, either native silver, or some fluid substance capable of producing it. Mr. Cronstedt mentions, in the Swedish Memoirs, a water flowing through a mine in Norway containing silver. Another instance is also mentioned of a silver guhr, in the Act. Erud. Upsal. 1720.

8. Mr. Von Justi pretends, that he has found silver mineralised by an *alkaline substance*; but he has not spoken sufficiently distinctly concerning it, to know whether he means a saline or earthy alkaline matter. Henkel also pretends, that by treating calcareous earth or certain clays with pyrites, silver may be obtained.

Ores of silver may be essayed [*see the article* ESSAY *of* ORES] by the same methods which are employed for the extraction of that metal from large quantities of ores; which methods are different, and suited to the different qualities of the several ores. *See* SMELTING *of* ORES. Or, in general, ores and earths containing silver may be essayed by the following Processes, which are copied from Dr. Mortimer's English edition of *Cramer's Art of Essaying Metals*, *Part* II. *Process* 1.

PROCESS I.

To precipitate Silver by means of Lead from fusible Ores.

" POUND the ore in a very clean iron-mortar into fine powder: of this weigh one docimastical centner or quintal, and eight of the like centners of granulated lead.

" Then have at hand the docimastical test (*see* PLATE I.), which must not as yet have served to any operation: pour into it about half of the granulated lead, and spread it with your finger through the cavity of it.

" Put upon this lead the pounded ore; and then cover it quite with the remainder of the granulated lead.

" Put the test thus loaded under the muffle of an essay-furnace, and in the hinder part of it: then make your fire, and encrease it gradually. If you look thro' the holes of either of the sliders, you will soon see that the pounded ore will be raised out of the melted lead, and swim upon it. A little after, it will grow clammy, melt, and be thrown towards the border of the test: then the surface of the lead will appear in the middle of the test like a bright disc, and you will see it smoak and boil: so soon as you see this,

" it

Such are the *blue silver-ore*, which is only a lead-ore containing much silver, and the *grey silver-ore*, which is a copper-ore containing silver.

"it will be proper to diminish the fire a "small matter for a quarter of an hour; so "as that the boiling of the lead may almost "cease. Then again, encrease the fire to "such a degree, that all may turn into a "thin fluid, and the lead may be seen, as "before, smoaking and boiling with great "violence. The surface of it will then "diminish by degrees, and be covered over "with a mass of scorias. Finally, have at "hand an iron hook ready heated, where-"with the whole mass must be stirred, espe-"cially towards the border; that in case "any small parcels of the ore not yet dis-"solved should be adherent there, they may "be brought down, taking great care not "to stir any the least thing out of the test.

"Now, if what is adherent to the hook "during the stirring, when you raise it "above the test, melts quickly again, and "the extremity of the hook grown cold is "covered with a thin, smooth, shining crust; "it is a sign that the scorification is perfect; "and it will be the more so as the said crust "adherent to the hook shall be colored "equally on every side: but in case, while "the scorias are stirred, you perceive any "considerable clamminess in them, and "when they adhere in good quantity to the "hook, though red-hot, and are inequally "tinged, and seem dusty or rough with "grains interspersed here and there; it is "a sign that the ore is not entirely turned "into scorias. In this case, you must with "a hammer strike off what is adherent to "the hook, pulverize it, and with a ladle "put it again into the test, without any loss "or mixture of any foreign body, and con-"tinue the fire in the same degree till the "scoria has acquired its perfection, and the "above-mentioned qualities. This once "obtained, take the test with a pair of "tongs out of the fire, and pour the lead, "together with the scoria swimming upon "it, into a cone made hot and rubbed with "tallow. Thus will the first operation "of the process be performed, which does "not commonly indeed last above three "quarters of an hour.

"With a hammer strike the scorias off "from the regulus grown cold, and again "examine whether they have the character-"istics of a perfect scorification; if they "have, you may thence conclude, that the "silver has been precipitated out of the ore "turned to scorias, and received by the "lead.

"When the scorification lasts longer than "we mentioned, the lead at last turns to "scorias or litharge, and the silver remains "at the bottom of the vessel: but the fire 'must be moderately supplied, and the 'vessels be extremely good, to produce this 'effect; for they seldom resist to the strength 'of the scorias long enough; so that the 'whole scorification may be brought to an "end; which has afterwards this inconve-"niency, that the silver is dissipated by "grains in the small hollows of the corroded "ore, and can hardly be well collected "again, when the ore has but little silver in "it. Nay, there is still more time to be "consumed to obtain the perfect destruction "of the lead, by means of the combined "actions of the fire and air, because the "scorias swimming at the top retard it con-"siderably.

"In this process, the sulphur and the "arsenic of the silver-ore, when the ore is "broken small, and extended widely in a "small quantity, are in part easily dissipated "by the fire, and in part absorbed by the "lead; the lighter part of which, swimming "upon the heavier, becomes very clammy "by means of the sulphur which is in the "ore; but when this is dissipated by the "violence of fire, it turns into glass or "scorias: but when arsenic is predominant "in the ore, the plumbeous part turns im-"mediately into a very penetrating and very "fusible glass, having a dissolving efficacy, "unless the arsenic lies hidden in a white "pyrite or cobalt. For this reason, the "fixed part of the ore, which is no silver, "is dissolved by that glass, melts, and as-"sumes the form of scorias. The unme-"tallic earths and the pure copper or lead-"ores thereto adherent are of this kind. The "silver then remains immutable, and being "freed of these heterogeneous bodies, which "are partly dissipated and partly melted, it "is precipitated and received by the remain-

DXIII. ORES *of* COPPER. Copper is found under ground

" ing regulus of lead. Therefore this process is completed by three distinct operations; viz. 1. By roasting. 2. By scorification. 3. By the melting precipitation of the silver, which is the result of the two former operations.

" The ore must be pulverised very fine in order to encrease the surface, that the dissipation of the volatiles and the dissolution by litharge may be sooner effected. This pulverising must then be done before the ore is weighed, because there is always some part of the ore adherent to the mortar or iron-plate on which it is made fine; which part being lost, the operation is not exact. *Erker* was in the right when he prescribed eight centners of lead for the subduing of fusible ores. Nevertheless, it must be owned that this quantity is superfluous in some cases. However, as the fluxibility of the silver-ore depends from the absence of stones, pyrites, &c. it is easy to see, that there are an infinite number of degrees of fluxibility which it would be needless to determine exactly, and most commonly very difficult to determine by the bare sight. Besides, a little more lead does not render the process imperfect; on the contrary, if you use too small a quantity of lead, the scorification is never completely made. Nay, there are a great many ores, containing sulphur and arsenic in plenty, that destroy a considerable quantity of lead: such are the red silver-ore, and that wherein there is a great deal of the steel-grained lead ore. If the fire must be sometimes diminished in the middle of the process, it is in order to hinder the too much attenuated litharge, which is continually generated out of the lead, from penetrating the pores of the test, and from corroding it; which is easily done when the fire is over-strong; for then the surface of the vessel which is contiguous to the lead contracts cavities, or being totally consumed by small holes, lets the regulus flow out of it. The vessels that are most subject to this inconvenience are those in the materials of which lime, plaster, and chalk are mixed. Nay, these bodies, which are of their nature refractory, being eroded during their scorification, at the same time, communicate a great clamminess to the scoria; so that a great quantity of the mass remains adherent to the test in the form of protuberances, when you pour it out; whereby a great many grains of the regulus are detained."

PROCESS II.

THE regulus obtained by the process I. contains all the silver of the ore, and the unscorified part of the lead. The silver may be afterwards separated from the lead, and obtained pure by *cupellation*; which process is described under the article of the Dictionary, ESSAY *of the* VALUE *of* SILVER.

PROCESS III.

IF the silver-ore cannot be washed clean, or if it be rendered refractory by a mixture of unmetallic earths and stones, the scorification of these earthy matters frequently cannot be completed by the process I. Cramer therefore directs that such ores shall be treated in the following manner [*Art of Assaying, Part* II. *Process* 3].

" Bruise the ore into an impalpable powder, by grinding in a mortar; to a docimastical centner of it, add a like quantity of glass of lead finely pulverised; for the more exactly these two are mixed together, the more easily the scorification afterwards succeeds. Put this mixture, together with twelve centners of lead, into the test, according to process I. then put the test under the muffle.

" Make first under it a strong fire, till the lead boils very well; when you see it so, diminish the violence of the heat, as was directed in the first process; but keep it thus diminished a little longer: then, finally, again encrease the fire to such a degree, till you perceive the signs of a perfect scorification and fusion. *See the whole Process* I. Now this process lasts a little longer than the foregoing, and requires a greater fire towards the end.

" It sometimes happens that a very refractory ore cannot be dissolved by litharge; and that a mass, which has the clamminess

in three different forms. 1. Native or virgin copper diversely ramified, which

"of pitch, swims upon the regulus and upon "the scorias themselves which are already "subdued in part: when you see this, shut "the vents of the furnace to diminish the "fire; then gently touch this refractory body "with a small iron cold hook, to which it "will immediately stick; take it off softly, "not to lose any thing; pound it into a fine "powder, adding a little glass of lead; and "put it again into the test; then con- "tinue the scorification, till it is brought "to its perfection. But you must always "examine the scoria of your refractory ore, "to see whether there may not be some "grains of regulus dispersed in it; for some- "times the scorias that grow clammy retain "something of the metal; which if you "suspect, pound the scoria into a fine dust, "and thus the grains of metal will appear, "if there are any left; because they can "never be pounded fine. The silver is sepa- "rated from this regulus by coppelling, as "in Process II.

"All earths and stones are refractory in "the fire; for, although some of them melt "naturally in the fire, as those that are "vitrifiable do; nevertheless, all the others, "a very few excepted, melt much more dif- "ficultly than metals, and never become "so thin in the fusion as is required for "the sufficient precipitation of a precious "metal. But litharge itself does not con- "veniently dissolve these refractory matters "by the help of fire alone, unless you add "some mechanical mixture to them; for "the very moment the said litharge pene- "trates through the interstices of the refrac- "tory ore, and begins to dissolve it, a tena- "cious mass is produced, which hardly "admits any farther dilution by the litharge. "You may see it plain, if you make colored "glasses with metallic calxes; if you pour "carelessly upon them a calx that gives a "color, you will never obtain that they may "be equally died on every side, even altho' "you should torture them for whole days "together in a great fire. Nay, glass already "made can never be diluted by only pouring "salts and litharge upon it. Wherefore, "you must use the artifice of glass-makers, "who, in the making of the most perfect "glasses, take great care before they put the "species of their ingredients into the fire, to have a mechanical mixture precede, or at least accede during the fusion itself; which is done here by pounding glass of lead mixt with the ore: but if you think that your glass of lead is not sufficiently fusible, you may add to it litharge melted first, and then pounded into a fine powder.

"As this scorification requires a longer and a greater fire than the foregoing, and as a greater quantity of litharge is more-over requisite to subdue the refractory scoria; it is easy to see why a much greater quantity of lead must be used here than in Process I. and, although less lead is often sufficient, it is nevertheless proper always to use the greatest quantity that can be necessary, lest, for instance, it should be necessary to try so many times the lead alone, to make it evident how much silver the lead when alone leaves in the coppel. Nor need you fear lest any thing of the silver be taken away by the lead, provided the coppels be good, and the coppelling duly put in execution: for you can hardly collect a ponderable quantity of silver out of the collected fume of the lead, which rises during the coppelling, as well as out of the litharge, that is with-drawn into the coppel."

PROCESS IV.

IF the ore be rendered refractory by pyrites, Cramer directs, that the silver should be precipitated by lead in the following manner. [*Art of Assaying*, *Part* II. *Proc.* 4.]

"Break your ore into a rough powder, "and put a centner of it into the test: put "upon this another test in the manner of a "tile; put it under the muffle hardly red- "hot: increase the fire by degrees. There "will always be a crackling: which being "ended, take away the upper test; for when "the vessels have been red-hot about one "minute, the ore ceases to split. Leave the "ore under the muffle till the arsenic and "the sulphur are for the most part eva- "porated; which you will know from the "cessation of the visible smoak, of the smell "of garlic, or the acid; then take away the "test, and leave it in a place not too cold, "that it may cool of itself.

"Pour out, without any dissipation, the "roasted

is much more rare than native silver. This native copper is not so ductile as

" roasted ore, and with a knife take away " what is adherent to the vessel; pound it " to a most subtle powder, and grind it together with an equal weight of glass of " lead; and, finally, scorify the whole collected ore in the same test wherein the " testing was made, unless it has contracted " chinks, as was described in Process III.

" *Remarks.* Yellow pyrites-ores contain " a very great quantity of sulphur, even " greater than is necessary to saturate the " metal that lies hidden in them. For which " reason this superfluous sulphur dissipates in " a middling fire; but if it had been mixed " with lead it would have rendered it refractory, nor could it afterwards be dissipated " from it without a considerable destruction " of the lead. The white arsenical pyrites " turn also a great quantity of lead into " glass, on account of the abundance of the " arsenic they contain. For which reason " these ores must be previously roasted, that " the sulphur and arsenic may be dissipated. " Nor need you fear lest any part of the " silver be carried away with the arsenic; " for when arsenic is separated from any " fixed body, by a certain degree of fire, it " carries nothing of that body away with " it."

P R O C E S S V.

SILVER may be precipitated from its ore by cupellation only, in the following Process, given by Cramer. [*Art of Assaying, Part* II. *Proc.* 9.]

" Pound one centner of ore; roast it in " the manner directed in the last process; " beat it to a most subtle powder; and if it " melts with difficulty on the fire, grind it " together with one centner of litharge, " which is not necessary when the ore melts " easily: then divide the mixture or the " powder of the ore alone into five or six " parts, and wrap up every one of them " severally in such bits of paper as can contain no more than this small portion.

" Put a very large coppel under the " muffle; roast it well first, and then put " into it sixteen centners of lead: when the " lead begins to smoak and boil, put upon it " one of the said portions with the small " paper it was wrapt up in, and diminish " the fire immediately, in the same manner " as if you would make a scorification in a " test, but in a lesser time. The small paper, " which turns presently to ashes, goes off of " itself, and does not sensibly encrease the " mass of the scorias. The ore proceeding " therefrom is cast on the border, and turns " to scorias very soon. Increase the fire again " immediately, and, at the same time, put " another portion of the ore into the coppel, " as was just now said. The same effects " will be produced. Go on in the same " manner, till all the portions are thrown in " and consumed in the lead. Finally, destroy the remaining lead with a stronger " fire.

" The silver that was in the ore and in the " lead will remain in the coppel. If you deduct from it the bead proceeding from the " lead, you will have the weight of the silver " contained in the ore. If the ore employed " was easy to be melted, all the scoria vanishes; " but if it was refractory or not fusible, all the " scoria does not always go away, but there " remains something of it now and then in " the form of dust. A great many ores and " metals may be tried in this way, except " only such as split and corrode the coppels. " There are likewise some of them which " must be previously prepared, in the same " manner as is required, to render them fit " for going through a scorification. *See the* " *foregoing Processes.*

" *Remarks.* The ore thrown at several " times upon lead boiling in a coppel may be " dissolved without the foregoing scorification: but this is very far from having an " equal success with all kinds of ores; for " there are ores and metals which resist very " much to their dissolution by litharge; and " which being on this account thrown on the " border, are not sufficiently dissolved; because the litharge steals away soon into the " coppel. Nevertheless, there are some others " which vanish entirely by this method, except the silver and gold that was contained " in them.

" A previous roasting is necessary, first, " for the reasons mentioned, and then because the ore thrown upon boiling lead " should not crackle and leap out; for, " having once passed the fire, it bears the " most sudden heat."

PRO-

as copper purified by fusions from the ore (*k*). 2. Copper is found in form of calx, of verdigreafe, of precipitates. Such are the minerals called filky copper ores, and feveral white and green earths. Thefe matters are only copper almoft pure and but little mineralifed, but which has been corroded, diffolved, precipitated, calcined by faline matters, by the action of the air, of water, and of earths (*l*). 3. Copper is frequently in a truly mineral ftate, that is,

PROCESS VI.

"*Silver may be precipitated out of the fame* "*bodies as were mentioned in the foregoing* "*proceffes by fcorification in a crucible.* "[*Cramer*, *Proc.* xv.]

"THE body out of which you intend to "precipitate filver muft be previoufly pre- "pared for a fcorification by pounding and "roafting, as mentioned in the former pro- "ceffes. Then in the fame manner, and "with the fame quantity of lead, put it in- "to a crucible ftrictly examined, that it "be entire, folid, not fpeckled with black "fpots, like the fcoria of iron, efpecially "at its inferior parts, and capable of con- "taining three times as much. Add befides "glafs gall and common falt, both very dry, "and enough, that when the whole is melted, "the falts may fwim at top at the height "of about half an inch.

"Put the crucible thus loaded into a "wind-furnace; fhut it clofe with a tile; "put coals round it, but not higher than "the upper border of the crucible. Then "light them with burning coals, and in- 'creafe the fire till the whole melts very 'thin, which will be done by a middling 'fire, maintained always equal, and never 'greater: leave it thus for about one quarter "of an hour, that the fcorification may be 'perfectly made. Take off the tile and 'ftir the mafs with an iron wire, and a lit- "tle after pour it out into the mould. When "the regulus is cleaned from fcorias, try "it in a teft by coppelling it.

"*Remarks*. The fcorification of any ore "whatever, or of any body fetched out of "ores, may indeed be made by this ap- "paratus, as well as in a teft under a muffle: "but it ferves chiefly to the end that a "greater quantity of metal may be melted "from it with profit. For you may put "many common pounds of it at one fingle "time into the crucible; but then you need "not obferve the proportion of lead pre- "fcribed in the foregoing procefs; nay, a "quantity of lead two or three times lefs "is fufficient, according to the different "qualities of the object. But the mafs will "certainly be fpilt, unlefs you chufe a very "good crucible; for there is no veffel "charged with litharge, that can bear a "ftrong fire having a draught of wind, with- "out giving way through it to the litharge.

"You add glafs-gall and common falt, "that they may forward the fcorification, "by fwimming at top; for the refractory "fcoria rejected by the litharge, and ad- "hering between this and the falts, that "fwim at top; is foon brought to a flux; "and the precipitation of the filver is "thereby accelerated. They alfo hinder "in a manner a fmall burning coal fallen "into the crucible, from fetting the litharge "a boiling, which troubles the operation; "for the litharge or glafs of lead, efpecially "that which is made without any addition, "fo foon as the phlogifton gets into it, "raifes into a foamy mafs, confifting of a "multitude of fmall bubbles very difficult "to be confined, unlefs the phlogifton be "entirely confumed, and the litharge re- "duced to lead, which fometimes rifes "above the border of the veffel."

Native metallic filver may be feparated from the ftones and earths with which it is intermixed, by *amalgamation with mercury*, which operation is to be performed in the fame manner as for the feparation of native gold; a detail of which fee at the article SMELTING *of* ORES.

The *corneous ore*, if it really be, as Cronftedt fays, a luna cornea, ought to be treated in fome of the methods directed for the reduction of luna cornea. *See* LUNA CORNEA.

(*k*) COPPER ORES. *Native Copper* is folid; or confifting of friable maffes, formed by precipitation of cupreous vitriolic waters, called *cément*, or *ziment copper*; or forming cryftallized cubes, or grains, leaves, branches, or filaments.

(*l*) *Calciform ores* are either pure calxes of copper, or are mixed with heterogeneous matters. 1. The *pure* are loofe friable ochre,

combined with sulphur, and with arsenic, with other metallic matters mixed with earths, and enveloped in different matrixes. These are the true copper ores. They have no regular forms except they partake of the nature of pyrites Their colors are very different, which depend chiefly on the proportion of the mineral substances composing them. Lastly, in almost all of them we may perceive green or blue colors, which always indicate an erosion or calcination of the copper. Most copper ores contain also some iron or ferruginous earth, to which the ochrey color is to be attributed, which might make us believe them to be ores of iron. Ores which contain much iron are the most difficultly fusible.

Copper-ores have almost all a yellow, golden, and shining color, by which they are easily distinguished. Some of them are colored with irises, and frequently have spots of verdegrise, by which also they are distinguishable from other ores. (*m*)

ochre, called *cæruleum montanum*, mountain blue, and *viride montanum*, mountain-green; and the *red indurated calx*, called improperly *glass copper ore*. 2. *Mixed* calciform ores are those in which the calx of copper is mixed; with *calcareous earth*, forming a mountain blue; with *iron*, forming a black calx; with *gypsum*, an indurated green ore, called *malachites*; and with *quartz*, a red ore.

(*m*) Copper is *mineralised*, 1. By *sulphur*, forming the *grey copper ore*, improperly called *vitreous* (minera cupri vitrea Wallerii). 2. By *sulphurated iron*, forming the *hepatic copper ore* (minera cupri hepatica Wallerii) of a brown yellow color. It is a kind of cupreous pyrites, and is called by Cronstedt minera cupri pyritacea. Sometimes it is of a blackish grey color, and is then called *pyrites cupri griseus* (minera cupri grisea Wallerii); sometimes of a reddish yellow, and tarnished with blue irises on its surface, when it is called *minera cupri la-urea*; when of a yellowish-green color, it is the *pyrites cupri flavo viridescens* cuprum sulphure & ferro mineralisatum Wallerii); and when of a pale-yellow color, it is the *pyrites cupri pallidé flavus*. Most of the above pyritaceous ores contain also some arsenic, but their sulphur is predominant. 3. *Copper mineralised by sulphur, iron, and arsenic. White copper-ore* (Minera cupri alba Wall.). This ore contains also some silver. 4. *Copper dissolved by vitriolic acid. Native blue vitriol.* 5. *Copper united with bitumens. Copper coal-ore.* This is a pitcoal from the ashes of which copper is obtainable. 6. Copper is also found in the mineral called *kupfer-nickel*.

Ores of copper may be *essayed* in methods similar to those employed for smelting of large quantities of ores (*see* SMELTING *of* ORES); or they may in general be essayed by the following processes.

PROCESS I.

[Extracted from *Cramer's Art of Assaying*, *Proc.* 30.]

" *To reduce and precipitate copper from a pure*
" *and fusible ore in a close vessel.*"

" MIX one, or, if you have small weights, " two docimastical centners of ore beat ex- " tremely fine, with six centners of the black " flux; and having put them into a crucible " or pot, cover them one inch high with " common salt, and press them down with " your finger: but let the capacity of the " vessel be such, that it may be only half " full; shut the vessel close; put it into " the furnace; heap coals upon it so that " it may be covered over with them a few " inches high; govern the fire in such a " manner, that it may first grow slightly " red-hot. Soon after you will hear your " common salt crackle; and then there will " be a gentle hissing noise. So long as this " lasts, keep the same degree of fire till it " is quite over. Then encrease suddenly " the fire, either with the funnel and cover " put upon the furnace, or with a pair of " bellows applied to the hole of the bot- " tom part, that the vessel may grow very " red-hot. Thus you will reduce and pre- " cipitate your copper in about a quarter of

Many copper ores are also rich in silver. Such is that called the white copper ore, the color of which is rather occasioned by arsenic than by silver, al-

" of an hour: then take out the vessel, and " strike with a few blows the pavement " upon which you put it, that all the small " grains of copper may be collected in one " mass.

" Break the vessel, when grown cold, in " two, from top to bottom, as nearly as " you can: if the whole process has been " well performed, you will find a solid, " perfectly yellow and malleable regulus " adhering to the bottom of the vessel, with " scorias remaining at top of a brown " color, solid, hard, and shining, from " which the regulus must be separated with " several gentle blows of a hammer; this " done, weigh it, after having wiped off " all the filthiness.

" A soft dusty and very black scoria is a " sign of a fire not sufficiently strong. Small " neat grains of copper reduced but not pre- " cipitated, and adhering still to scorias, " especially not very far from the bottom, " and an unequal and ramificated regulus, " are signs of the same thing. A solid, " hard, shining, red-colored scoria, espe- " cially about the regulus, or even the re- " gulus itself when covered with a like " small crust, are signs of an excess in the " degree and duration of the fire.

" *Remarks.* All the ores which are easily " melted in the fire are not the objects of " this process; for they must also be very " pure. Such are the vitreous copper ores." [Mr. Cramer means, I presume, the red calciform ore called improperly *glass ore*, and not the *minera cupri vitrea* of Wallerius, which being compofed of copper mineralised by sulphur, could not be treated properly by this process, in which no previous roasting is required. The sulphur of this ore would with the alkali of the black flux form a hepar, from which the metal would not precipitate,] " but " especially the green and azure-colored " ores, and the cæruleum & viride monta- " num, which are not very different from " them. But if there is a great quantity " of arsenic, sulphur, or of the ore of " another metal and semi-metal joined to " the ore of copper, then you will never " obtain a malleable regulus of pure copper, " tho' ores are not always rendered refractory " by the presence of these."

PROCESS II.

[*Cramer Pr.* xxxvii.]

" *To reduce and precipitate copper out of ores " rendered refractory by earth and stones that " cannot be washed off.*

" BEAT your ore into a most subtil pow- " der, of which weigh one or two centners, and " mix as much sandiver to them. This " done, add four times as much of the black " flux with respect to the ore; for by this " means, the sterile terrestrial parts are better " disposed to a scorification, and the re- " ducing and precipitating flux may act " more freely upon the metallic particles " freed from all their incumbrances.

" As for the rest, make the apparatus as " in last process: but you must make the " fire a little stronger for about half an hour " together. When the vessel is grown cold " and broken, examine the scorias, whe- " ther they are as they ought to be. The " regulus will be as fine and ductile as the " foregoing.

" *Remarks.* As these copper-ores hardly " conceal any sulphur and arsenic in them, " the roasting would be of no effect, and " much copper would be lost. For no me- " tallic calx, except those of gold and silver, " improperly so called, can be roasted, with- " out you find a part of the metal lost after " the reduction."

PROCESS III.

" *To precipitate copper out of an ore * that con- " tains iron.* [*Cramer Proc.* xxxviii.]

" DO all according to last process. But " you will find after the vessel is broken, a " regulus upon no account so fine, but less " ductile, wherein the genuine color of the " copper does not perfectly appear, and " which must be further purified.

* Mr. Cramer still means the calciform ores only, and not the mineralised ores of copper.

though it contains so much silver as to be enumerated by several mineralogists amongst silver ores.

" *Remarks.* The fire used in this operation " is not so strong that the iron should turn " to a regulus. But as copper is the men- " struum of iron, which is of itself very re- " fractory in the fire; for this reason, while " the ore and the flux are most intimately " mixt and confounded by trituration, the " greatest part of the iron being dissolved by " the copper, turns into a regulus along " with it."

PROCESS IV.

[*Cramer Proc.* xxxix.]

" *The roasting of a pyritose, sulphureous, arse- nical, semi-metallic copper ore.*

" BREAK two docimastical centners of " the ore to a coarse powder, put them into a " test covered with a tile, and place them " under the muffle of a docimastical furnace. " But the fire must be so gentle, that the muf- " fle may be but faintly red-hot. When the " ore has decrepitated, open the test, and " continue the fire for a few minutes; then " increase it by degrees, that you may see " the ore perpetually smoaking a little: in " the mean time, it is also proper now and " then to stir it up with an iron hook. " The shining particles will assume a dark " red or blackish color. This done, take " out the test, that it may grow cold. If " the small grains are not melted, nor " strongly adherent to each other, hitherto " all will be well; but if they run again " into one single cake, the process must be " made again with another portion of the " ore, in a more gentle fire.

" When the ore is grown cold, beat it " to a powder somewhat finer, and roast it " by the same method as before; then take " it out, and if the powder is not melted " yet, beat it again to a most subtil powder; " in this you are to take care that nothing be " lost.

" Roast the powder in a fire somewhat " stronger, but for a few minutes only. If you " do not then find the ore any way inclined " to melt, add a little tallow, and burn it " away under the muffle, and do the same " another time again, till the fire being very " bright, you no longer perceive any sul- " phureous, arsenical, unpleasant smell, or " any smoak; and there remains nothing " but a thin, soft powder, of a dark red, or " blackish color.

" *Remarks.* Every pyrites contains iron, " with an unmetallic earth: to which sul- " phur, or arsenic, and most commonly " both always join. Besides, there is cop- " per in many pyrites; but sometimes more, " and sometimes less: some of them are alto- " gether destitute of copper; therefore, so " much as pyrites differ with regard to the " proportion of their constituent particles, so " much do they differ as to their disposition " in the fire. For instance, the more cop- " per there is in pyrites, the more it inclines " to colliquation. The more sulphur and " arsenic it has in it, the more quickly the " melting of it will be procured, and the " reverse: the more iron and unmetallic " earth it contains, the more it proves re- " fractory in the fire. Now if such pyrites " melt in the roasting; as happens to some " of them, if they grow but red-hot; the " sulphur and arsenic that lies hidden there- " in are so strictly united with the fixed " part, that you would in vain attempt to " dissipate them. Nay, in this case, when " it is reduced again into a powder, it re- " quires a much greater time and accuracy " in the regimen of the fire to perform the " operation. For this reason, it is much " better to repeat it with new pyrites. But " you can roast no more than the double " quantity at once of the ore you have " a mind to employ in the foregoing ex- " periment; to the end that, the precipita- " tion by fusion not succeeding, there may " remain still another portion entire; lest " you should be obliged to repeat a tedious " roasting. If you see the signs of a ferreous " refractory pyrites, the operation must be " performed with a greater fire, and much " more quickly. However, take care not to " do it with too violent a fire: for a great " deal of copper is consumed not only " by the arsenic, but also by the sulphur; " and this happens even in vessels shut very " close, when the sulphur is expelled by " a fire not quite so strong; which a re- " iterated and milder sublimation of the sul-

" phur

Laſtly, the pyrites of a golden-yellow color which contains copper and ſulphur, and the white pyrites which contains copper and arſenic, are conſidered

" phur in a veſſel both very clean and well " cloſed, will clearly ſhew.

" When the greateſt part of the ſulphur " and the arſenic is diſſipated, by ſuch cauſes " as promote colliquation you may make " a ſtronger fire: but then it is proper to " add a little of ſome fat body; for this diſ- " ſolves mineral ſulphur; it changes the " mixture of it in ſome part, which, for in- " ſtance, conſiſts in a certain proportion of " acid and phlogiſton, and at the ſame time " hinders the metallic earth from being re- " duced into copper, by being burnt to an " exceſs. From theſe effects the reaſon is " plain, why aſſayers produce leſs metals in " the trying of veins of copper, lead, and " tin, than ſkilful ſmelters do in large " operations. For the former perform the " roaſting under a muffle, with a clear fire, " and without an oily reducing menſtruum; " whereas the latter perform it in the middle " of charcoal or of wood, which perpetually " emit a reductive phlogiſton.

" The darker and blacker the powder of " the roaſted ore appears, the more copper " you may expect from it. But the redder " it looks, the leſs copper and the more iron " it affords; for roaſted copper diſſolved by " ſulphur or the acid of it is very black, and " iron, on the contrary, very red.

" It is eaſy to conceive, that there is as " great a difference between the ſeveral " kinds of that metal called black copper, " as there is between the pyritoſe and other " copper-ores, accidentally mixed with other " metallic and ſemi-metallic bodies. For all " the metals, the ores of which are intermixed " with the copper-ores, being reduced, are pre- " cipitated together with the copper; which " is brought about by means of the black flux. " Wherefore iron, lead, tin, the reguline " part of antimony, biſmuth, moſt common- " ly are mixed with black copper in a mul- " titude of different proportions. Nay it is " ſelf-evident, that gold and ſilver, which are " diſſolvable by all theſe matters, are col- " lected in ſuch a regulus, when they have " been firſt hidden in the ore. Beſides, " ſulphur and arſenic are not always al- " together abſent. For they can hardly be " expelled ſo perfectly by the many pre- " ceding roaſtings, but there remain ſome " veſtiges of them, which are not diſſipated " by a ſudden melting, eſpecially in a cloſe " veſſel, wherein the flux ſwimming at top " hinders the action of the air. Nay arſe- " nic is rather fixed by the black flux, and " aſſumes a reguline ſemi-metallic form, " while it is at the ſame time preſerved from " diſſipating by the copper.

PROCESS V.

[*Cramer Pr.* xl.]

" *The precipitation of copper out of roaſted ore " of the laſt proceſs.*

" DIVIDE the roaſted ore into two parts: " each of them ſhall go for a centner: add to " it the ſame weight of ſandiver, and four " times as much of the black flux, and mix " them well together. As for the reſt, do all " according to the proceſs I.† The preci- " pitated regulus will be half malleable, " ſometimes quite brittle, now and then " pretty much like pure copper in its " color, but ſometimes whitiſh, and even " blackiſh. Whence it is moſt commonly " called *black copper*, though it is not always " of ſo dark a dye.

PROCESS VI.

[*Cramer, Proc.* xliv.]

" *To reduce black copper into pure copper by " ſcorification.*

" SEPARATE a ſpecimen of your black " copper, of the weight of two ſmall doci- " maſtical centners at leaſt; and do it in the " ſame manner, and with the ſame pre- " cautions, as if you would detect a quan- " tity of ſilver in black copper.

" Then with lute and coal-duſt make a " bed in the cavity of a teſt moiſtened: " when this bed is dry, put it under the " muffle of the docimaſtical furnace, in the " open orifice of which there muſt be bright " burning coals, wherewith the teſt muſt " likewiſe be ſurrounded on all parts. When

as copper ores by ſeveral chemiſts and naturaliſts. *See* PYRITES. Henckel and Cramer remark, that no proper ore of copper is known which does not contain a conſiderable quantity of arſenic.

DXIV. ORES *of* LEAD. Lead is ſeldom found native and malleable. Neither is it found in form of calx or precipitate, as copper is,

"the whole is perfectly red-hot, put your "copper into the fire, alone, if it contains "lead; but if it is altogether deſtitute of "it, add a ſmall quantity of glaſs of lead, "and with a pair of hand-bellows increaſe "the fire, that the whole may melt with "all ſpeed: this done, let the fire be made "a little leſs violent, and ſuch as will ſuf"fice to keep the metallic maſs well melted; "and not much greater. The melted maſs "will boil, and ſcorias will be produced, "that will gather at the circumference. "All the heterogeneous matters being at "laſt partly diſſipated, and partly turned to "ſcorias, the ſurface of the pure melted "copper will appear. So ſoon as you ſee it, "take the pot out of the fire, and extinguiſh "it in water: then examine it in a ballance, "and if lead has been at firſt mixt with "your black-copper, add to the regulus re"maining of the pure copper, one fifteenth "part of its weight which the copper has "loſt by means of the lead, then break it "with a vice; and thus you will be able "to judge by its color and malleability, and "by the ſurface of it after it is broken, "whether the purifying of it has been well "performed, or no. But whatever caution "you may uſe in the performing of this pro"ceſs, the product will nevertheleſs be al"ways leſs in proportion than what you "can get by a greater operation, provided "the copper be well purified in the ſmall "trial.

"*Remarks.* This is the laſt purifying "of copper, whereby the ſeparation of the "heterogeneous bodies begun in the fore"going proceſs is completed as perfectly "as it poſſibly can be. For, except gold "and ſilver, all the other metals and ſemi"metals are partly diſſipated and partly "burnt, together with the ſulphur and "arſenic. For in the fuſion they either "turn of themſelves to ſcoria or fumes, or "this is performed by means of iron, which "chiefly abſorbs ſemi-metals, ſulphur and "arſenic, and the deſtruction of it is at the "ſame time accelerated by them. Thus "the copper is precipitated out of them pure; "for it is ſelf-evident, that the unmetallic "earth is expelled, the copper being re"duced from a vitreſcent terreſtrial to a me"tallic ſtate; and the arſenic being diſſipated, "by means of which the ſaid earth has been "joined to the coarſer regulus's of the firſt "fuſion. But there is at the ſame time "a good quantity of the copper that gets "into the ſcorias: however, a great part "of it may be reduced out of them by re"peating the fuſion.

"The fire in this proceſs muſt be applied "with all imaginable ſpeed, to make it ſoon "run: for if you neglect this, much of "your copper is burnt: becauſe copper that "is only red-hot, cleaves much ſooner, and "in much greater quantity, into half ſcorified "ſcales, than it is diminiſhed in the ſame "time when melted. However, too im"petuous a fire, and one much greater than "is neceſſary for the fuſion of it, deſtroys a "much greater quantity of it, than a fire "ſufficient only to put it in fuſion would "do. For this reaſon, when the purifying "is finiſhed, the body melted muſt be ex"tinguiſhed in water together with the "veſſel, leſt being already grown hard, it "ſhould ſtill remain hot for a while; which "muſt be done very carefully to prevent dan"gerous exploſions.

"The ſcoria of the above proceſs fre"quently contains copper. To extract "which, let two or three docimaſtical cent"ners of the ſcoria, if it be charged with "ſulphur, be beat to a ſubtil powder, and "mix it, either alone, or, if its refractory "nature requires it, with ſome very fuſible, "common, pounded glaſs without a re"ducing ſaline flux, and melt it in a cloſe "veſſel, and in a fire having a draught of "air; by which you will obtain a regulus.

"But when the ſcoria has little or no ſul"phur at all in it, take one centner of it, "and with the black flux, manage it as "you do the fuſible copper ore; [Proceſs I.] "by which you will have a pure regulus."

PRO-

because it is much less liable to lose its phlogiston by the action of air and water: therefore almost all lead is found naturally mineralised.

PROCESS VII.

[The following Process is translated from Mr. Gellert's *Elements of Essaying*, and describes a new method of essaying ores, concerning which, see a note (*n*) subjoined to the article of this Dictionary ESSAY *of* ORES.]

To essay Copper-ores.

ROAST a quintal of ore [in the manner described in Process IV.]; add to it an equal quantity of borax, half a quintal of fusible glass, and a quarter of a quintal of pitch: put the mixture in a crucible, the inner surface of which has been previously rubbed with a fluid paste of charcoal-dust and water: cover the whole with pounded glass mixed with a little borax, or with decrepitated sea-salt: put a lid on the crucible, which you will place in an air-furnace, or in a blast-furnace: when the fire shall have extended to the bottom of the coals, let it be excited briskly during half an hour, that the crucible may be of a brisk red color: then withdraw the crucible; and when it is cold, break it: observe if the scoria be well made: separate the regulus, which ought to be semi-ductile; and weigh it. This regulus is *black copper*, which must be purified, as in Pr. VI.

If the ore be very poor, and inveloped in much earthy and stony matters, to a quintal of it, a quintal and a half of borax, a quarter of a quintal of pitch, and ten pounds of calx of lead or minium, must be added. The calx of lead will be revived, and will unite with the scattered particles of the copper, and together with these will fall to the bottom of the crucible, forming a compound regulus. When the ores of copper are very rich, half a quintal of borax and a quarter of a quintal of glass will be sufficient for the reduction. If the ore is charged with much antimony, a half or three quarters of a quintal of clean iron filings may be added; otherwise the large quantity of antimony might destroy the copper, especially if the ore contained no lead. If iron be contained in copper-ore, as in pyrites, some pounds of antimony, or of its regulus, may be added in the essay; as these substances more readily unite with iron than with copper, and therefore disengage the latter metal from the former.

PROCESS VIII.

To essay Ores of Copper by humid Solution.

SOME pyrites and ores contain so small a quantity of copper, that it cannot be separated by the above processes, but is destroyed by the repeated roastings and fusions. These, and indeed any copper-ores, may be essayed by humid solution, or by menstruums.

1. By roasting a sulphureous ore, the sulphur is burnt or decomposed, its phlogiston, with part of the acid evaporating, while the remaining part of the acid combines with the metals, especially with the copper and the iron contained in the ore. Accordingly, from an ore thus roasted, a vitriolic solution may be obtained by lixiviation with warm water, especially if the ore has been exposed, during a few days after it has been roasted, to a moist air; as the water thus gradually applied better unites with the combination of the metallic calxes with the concentrated vitriolic acid of the sulphur: but all the copper is not thus reduced by one operation to a vitriol. More sulphur must therefore be combined with the residuous ore by fusion, and must be again burnt off; that the remaining part of the copper may be attacked by some of the acid of the sulphur. By repeating this operation, almost all the copper and iron will be reduced to a vitriolic lixivium, from which the copper may be separated and precipitated by adding clean pieces of iron.

2. Copper-ores may be more easily essayed by humid solution, in the following manner:

Roast the mineralised ores in the manner directed in Process IV. and pulverise them. If the ores be calciform, they do not require a previous roasting. Put this powder into a matrass capable of containing ten times the quantity of the ore: pour upon the ore some water: set the matrass in a sand-bath, that the

Lead is generally mineralised by sulphur. Its ores have a dark white, but a shining metallic color. These ores, although they form irregular masses, are internally regularly disposed, and seem to be composed of cubes of different sizes applied to each other, but not adherent. These ores are generally distinguished by the name *Galena*. They commonly contain about three quarters of lead and a quarter of sulphur. They are accordingly heavy and fusible, although much less so than pure lead.

Most lead-ores contain silver, none but those of Willach in Carinthia are known to be quite free from it: some of them contain so much of it, that they are considered as improper ores of silver. The smaller the cubes of galena are, the larger quantity of silver has been remarked to be generally contained. (*n*)

the water may boil: pour off the lixivium: add to the residuous ore more water with some vitriolic or marine acid: digest as before in the sand-bath, and add this lixivium to the former: repeat this operation, till you find that the acid liquor dissolves no more metal.

By adding clean plates of iron, you may precipitate the copper, which ought then to be collected, fused with a little borax and charcoal dust, and weighed.

We may remark, that although copper is not soluble by a dilute vitriolic acid, yet the calx of it obtained by roasting the ore, and also the calciform ores, are readily soluble in that acid.

3. Stahl advises to essay copper-ores by boiling them, after they have been roasted and powdered, in water, together with tartar and common salt, or with alum and common salt: but I have not found this method so effectual as the preceding (2).

(*n*) Lead-Ores. Cronstedt doubts whether any native lead has been found. Linnæus says, he has seen what externally appeared to be such. The Author of the Dictionary is mistaken when he says, that no calx of lead is found. As lead unites strongly with vitriolic acid, we might expect to meet ochres of this metal as well as of copper. Accordingly, we find some *calciform ores* of lead. 1. A pure calx of lead, in form of a friable ochre, *cerussa nativa*, found on the surface of galena; or it is indurated with a radiated or fibrous texture, of a white or yellowish-green color, and resembling spar; it is called *spatum plumbi*, *sparry lead-ore*, and *lead-spar*. 2. A calx of lead is found mixed with calx of arsenic, forming the ore called *arsenicated lead-spar*. Sometimes also that calx is mixed with calcareous earth.

Lead is mineralised, 1. With *sulphur*; such are the several kinds of steel-grained and tesselated *galenas*, which also contain generally some silver. 2. With *sulphurated iron and silver*. It is fine-grained or tessellated, and is distinguishable from the former by yielding a black slag when scorified, whereas the former yields a yellow slag. 3. With *sulphurated antimony and silver*. *Plumbum stibiatum Linnæi*. Its color is similar to that of galena, and its texture is striated. 4. With *sulphur and arsenic*. This ore is soft, almost malleable, like lead. From this ore lead may be melted by the flame of a candle.

Lead-ores may be essayed by means of the black flux, in the manner directed by Mr. Cramer, and described in the Dictionary at the article Essay *of* Ores; or by the following process of Mr. Gellert.

Mix a quintal of roasted lead-ore with a quintal of calcined borax, half a quintal of glass finely pulverised, a quarter of a quintal of pitch, and as much of clean iron-filings: put this mixture into a crucible wetted with charcoal-dust and water: place the crucible before the nozzle of the bellows of a forge, and when it is red, raise the fire during fifteen or twenty minutes; then withdraw the crucible, and break it when cold.

Some very fusible ores, such as the galena of Derbyshire, may be essayed, as large quantities of it are smelted, without previous roasting, and without addition, merely by fusion during a certain time. For this purpose nothing more is requisite than to keep the ore melted in a crucible with a moderate heat, till all the sulphur is destroyed, and the metal be collected. To prevent the destruction of any part of the metal after it is separated from the sulphur, some charcoal dust

may

DXV. T I N - O R E S. Tin is very ſeldom found pure, but almoſt always mineraliſed, and chiefly by arſenic.

The richeſt ore of arſenic is of an irregular form, of a black or tarniſhed color, and almoſt the heavieſt of all ores. The cauſe of this extraordinary weight is, that it contains much more arſenic than ſulphur, whereas moſt ores contain more ſulphur than arſenic.

The moſt common tin-ore is of the color of ruſt, which proceeds from a quantity of iron, or of iron-ore mixed with it. The tin-ores of Saxony and Bohemia appear to be all of this kind.

One kind of tin-ore is ſemi-tranſparent and like ſpar. Laſtly, ſeveral kinds of garnets are enumerated by mineralogiſts amongſt tin-ores, becauſe they actually contain tin.

The county of Cornwall, in England, is very rich in tin-ores, and the tin contained in them is very pure. From tin-mines in the Eaſt-Indies tin is brought, called *Malacca tin.* No mines of tin have been diſcovered in France; only in Bretagne garnets are found which contain ſome tin. *(o)*

DXVI. O R E S *of* I R O N. No iron is found in its metallic ſtate, although ſeveral ſands and earths have the appearance of iron, and are even attractable by a magnet.

may be thrown over the ore, when put into the crucible: but if the galena be mixed with pyrites, eſpecially arſenical pyrites, it requires much roaſting and ſaline fluxes.

(*o*) TIN-ORES. *Native tin* is ſaid to have been found in Saxony and Malacca. Its ores are all of the calciform kind, excepting *black-lead*, which appears to be tin *mineraliſed by ſulphur and iron.* See MOLYBDENA.

The *calciform ores* of tin are, 1. *Tin-ſtone*, which is of a blackiſh-brown color, and of no determinate figure; and *tin-grains*, or *cryſtals of tin*, which reſemble garnets, and are of a ſpherical or polygonal figure, which they have probably acquired by the attrition of their angles. The tin-ſtone ſeems to conſiſt of attrited tin-grains. This ore is calx of tin united with calx of arſenic, and frequently with calx of iron. 2. *Garnets* are ſaid to contain calx of tin united with calx of iron. 3. *Mangan*eſe is ſaid alſo to contain tin. *See* MANGANESE.

Ores of tin may be eſſayed in the ſame manner, according to Cramer, as he directed for the eſſay of lead-ores. *See* ESSAY *of* ORES. He further makes upon this eſſay the following remarks.

1. Tin-ore, on account of its greater gravity, admits better of being ſeparated, by elutriation or waſhing, from earths, ſtones and lighter ores. 2. A moſt exact ſeparation of earths and ſtones ought to be made, becauſe the ſcorification of theſe by fluxes requires ſuch a heat as would deſtroy the reduced tin. 3. The iron ought to be ſeparated by a magnet. 4. By a previous roaſting, the arſenic is diſſipated, which would otherwiſe carry off a great deal of tin along with it in a melting heat, would change another part of it into aſhes, and would vitiate the remaining tin. 5. The eſſay of tin is very precarious and uncertain; becauſe tin once reduced is eaſily deſtructible by the fire, and by the ſaline fluxes requiſite for the reduction.

Mr. Gellert directs, that ores of tin ſhould be eſſayed in the following manner:

Mix a quintal of tin-ore, waſhed, pulveriſed, and twice roaſted, with half a quintal of calcined borax, and half a quintal of pulveriſed pitch: theſe are to be put into a crucible moiſtened with charcoal-duſt and water, and the crucible placed in an air-furnace: after the pitch is burnt, give a violent fire during a quarter of an hour; and then withdraw your crucible. If the ore be not very well waſhed from the earthy matters, as it ought to be, a larger quantity of borax is requiſite, with ſome powdered glaſs, by which the too quick fuſion of the borax is retarded, and the precipitation of the earthy matters is prevented. If the ore contains iron, to the above mixture may be added ſome alkaline ſalt.

Neither is iron generally mineralised so distinctly as other metals are, unless in pyrites and ores of other metals.

Most of the minerals called iron-ores have an earthy, rusty, yellowish or brownish appearance, which proceeds from the facility with which the true iron-ores are decomposed.

Iron is the most common and most abundant of all metals. In Europe, at least, we cannot find an earth, a sand, a chalk, a clay, a vitrifiable or calcinable stone, or even the ashes of any substance, which do not contain an earth convertible into iron. All earths and stones which are naturally yellow or red, and all those which acquire these colors by calcination, receive them from the ferruginous earth mixed with them. The yellow and red ochres consist almost solely of this earth: the black and heavy sands are generally very ferruginous.

One of the richest iron-ores is a heavy stone, the surface of which, when newly broken, is red and bluish, and is exceedingly hard. A quintal of this ore furnishes from sixty to eighty pounds of the best iron by a single fusion, according to Mr. Cramer.

The iron-ore most commonly found is a stone of the color of rust, of an intermediate weight betwixt those of ores in general and of unmetallic stones. This ore has no determinate form, and easily furnishes an iron of good quality.

Blood-stone or hematites, sanguine or red-chalk, and emery, are iron-ores; some of which, for instance, blood-stone, are almost all iron. Most of these substances require but a slight calcination to be rendered very attractable by a magnet, and soluble in aqua fortis: but the iron obtained from them is of a bad quality, and they are therefore neglected. Iron from the hematites is very brittle; that obtained from ochres is red-short. All these iron-ores are so refractory, that they can scarcely be fused.

Iron-ores are very various in their form; or rather they have no determinate form. Sometimes they are earths, sometimes stones, sometimes grains. Accordingly, those naturalists who attend only to the external form of things in classing and subdividing minerals, have been obliged to multiply the names of iron-ores: hence they are called *iron-ores in form of pease, of beans, of coriander seeds, of pepper-corns, of cinnamon,* &c. which Mr. Cramer treats as ridiculous trifles. *(p)*

(*p*) Ores *of* Iron. I. Malleable *native iron* is mentioned by Wallerius, Linnæus, and Cartheuser. II. The *calciform ores* of iron are pure, or mixed. The *pure* calciform ores are, 1. Friable, as the *martial ochre*, which is either in powder, or concreted, as the *bog-ore*; or, 2. they are indurated, *Hematites. See* Hematites. The *mixed* calciform ores consist of the calx of iron mixed with heterogeneous substances: 1. With *calcareous earth*; forming the *white spathose* iron ore. 2. With *siliceous earth*, forming *martial jasper*. 3. With *garnet-earth*, forming *garnets* and *basaltes*. 4. With *argillaceous earths*, forming *boles*. 5. With *micaceous earth*, forming *colored micas*. 6. With *manganese. See* Manganese. 7. With an *unknown earth*, which hardens like cement in water; *Terras*. This is chiefly found in the neighbourhood of volcanos. III. Iron is *mineralised*, 1. With *sulphur*, forming *martial pyrites*; *black iron-ore*, which is magnetic, the quantity of sulphur being very small; the *load-stone*. With *arsenic*; *white pyrites*. 3. With *sulphur and arsenic*; the *arsenical pyrites*. 4. With *vitriolic acid*; *native martial vitriol*. 5. With *phlogiston*; *martial coal-ore*. 6. With other sulphurated and arsenicated metals.

Ores of iron may be essayed by the following Processes.

PRO-

DXVII. ORES *of* MERCURY. Mercury is ſometimes found pure, fluid, and in its proper metallic ſtate, only mixed with earths and ſtones. Such are the ores of mercury found near Montpellier, in Tuſcany, and in other places.

PROCESS I.

[CRAMER's *Art of Eſſaying*, *Proceſs* 54.]

To reduce a precipitate Iron out of its Ore in a cloſe Veſſel.

"ROAST for a few minutes in a teſt "under a muffle, and with a pretty ſtrong "fire, two centners of the ſmall weight of "your iron ore groſsly pulveriſed; that the "volatiles may be diſſipated in part, and the "ore itſelf be ſoftened in caſe it ſhould be "too hard. When it is grown cold, beat "it extremely fine, and roaſt it a ſecond "time, as you do the copper-ore, but in a "much ſtronger fire, till it no longer emits "any ſmell; then let it grow cold again. "Compoſe a flux of three parts of the white "flux, with one part of fuſible pulveriſed "glaſs, or of the like ſterile unſulphureous "ſcorias, and add ſandiver and coal-duſt, of "each one half-part; add of this flux three "times the quantity of your roaſted ore, "and mix the whole very well together; "then chuſe a very good crucible, well "rubbed with lute within, to ſtop the pores "which may be here and there unſeen; put "into it the ore mixed with the flux; cover "it over with common ſalt; and ſhut it cloſe "with a tile and with lute applied to the "points.

"Put the wind-furnace upon its bottom "part, having a bed made of coal-duſt. [*See* "*Plate* III.] Introduce beſides into the fur- "nace a ſmall grate ſupported on its iron "bars, and a ſtone upon it; whereon the "crucible may ſtand as on a ſupport: ſur- "round the whole with hard coals, not "very large, and light them at top; when "the veſſel begins to grow red, which is "indicated by the common ſalt's ceaſing to "crackle, ſtop with groſs lute the holes of "the bottom part, except that in which the "nozzle of the bellows is received: blow "the fire, and excite it with great force, "adding now and then freſh fuel, that the "veſſel may never be naked at top: having "thus continued your fire in its full ſtrength "for three quarters of an hour, or for a "whole hour, take next the veſſel out of it, "and ſtrike ſeveral times the pavement upon "which it is ſet, that the ſmall grains of "iron which happen to be diſperſed may "be collected into a regulus, which you "will find after having broken the veſſel.

"When the regulus is weighed, try its "malleability; then make it red-hot; and "when ſo, ſtrike it with a hammer: if it "bears the ſtrokes of a hammer, both when "red-hot and when cold, and extends a "little, you may pronounce your iron very "good: but if, when either hot or cold, it "proves brittle, you may judge it to be not "quite pure, but ſtill in a ſemi mineral "condition.

"*Remarks.* The arſenic, but eſpecially "the ſulphur, muſt be diſſipated by roaſting; "for the former renders the iron brittle, and "the latter not only does the ſame, but, be- "ing managed in a cloſe veſſel, with a ſaline "alkaline flux, turns to liver of ſulphur; to "the action of which iron yielding in every "reſpect, it can upon no account be preci- "pitated; and if not the whole, a great part "of it, at leaſt, is retained by the ſulphu- "reous ſcoria; ſo that in this caſe you com- "monly in vain look for a regulus.

"The iron obtained from this firſt preci- "pitation has hardly ever the requiſite duc- "tility, but is rather brittle: the reaſon of "which is, that the ſulphur and arſenic re- "main in it; for notwithſtanding that the "greateſt part of theſe is diſſipated by roaſt- "ing, yet ſome part adheres ſo ſtrictly, that "it can never be ſeparated but with abſor- "bent, terreſtrial, alkaline ingredients, that "change the nature of the ſulphur. For "which reaſon, in larger operations, they "add quicklime, or marble-ſtones that turn "into quicklime; which, while they abſorb "the ſaid minerals, are, by it, and by help "of the deſtroyed part of the iron, brought "to a fuſion, and turn to a vitrified ſcoria; "although, at other times, they reſiſt ſo "much by their own nature a vitrification. "Another cauſe of the brittleneſs of iron is the

But the largest quantity of the mercury found in the earth is mineralised by sulphur, and consequently is in the form of cinnabar. *See* CINNABAR.

"the unmetallic earth, when it is not yet "separated from it; for the iron-ore contains a great quantity of it, and in the "melting remains joined with the reguline "part: whence the iron is rendered very "coarse and brittle. Some iron-ores are altogether untractable: nevertheless, the "reguluses produced out of them, when "broken, have sometimes a neat semimetallic look; which proceeds undoubtedly "from a mixture of a small quantity of some "other metal or semimetals.

PROCESS II.

[The following Process for essaying iron-ores, and ferruginous stones and earths, is extracted from Mr. Gellert's *Elements of Essaying.*]

ROAST two quintals of iron-ore, or of ferruginous earth: divide the roasted matter into two equal parts; to each of which add half a quintal of pulverised glass, if the substance be fusible, and contains much metal; but if otherwise, add also half a quintal of calcined borax. If the roasting has entirely disengaged the sulphur and arsenic, an eighth part, or even half a quintal, of quicklime may be added. With the above matters, mix twelve pounds of charcoal powder.

Take a good crucible, and cover the bottom and sides of its inner surface with a paste made of three parts of charcoal-dust and one part of clay beat together. In the hollow left in this paste put the above mixture; press it lightly down; cover it with pulverised glass; and put on the lid of the crucible.

Place two such crucibles at the distance of about four fingers from the air-pipe, in such a manner that the air shall pass betwixt them at about the third part of the height from the bottom: fill the space betwixt the two crucibles with coals of a moderate size: throw lighted coals upon them, that the fire may descend and make them red-hot from top to bottom: at first let the bellows blow softly, and afterwards strongly during an hour, or an hour and a quarter: then take away the crucible, and break it when cold. A regulus will be found in the bottom, and sometimes some small grains of iron in the scoria, which must be separated and weighed along with the regulus: then try the regulus, whether it can be extended under the hammer, when hot and when cold.

Remarks. To disengage a metal from the earthy matters mixed with it by fire, we must change these matters into scoria or glass. This change may be effected by adding some substance capable of dissolving these matters; that is, of converting them into a scoria or glass, from which the metallic matters may, by their weight, separate and form a regulus at bottom. Fixed alkali, which is an ingredient of the black and of the white flux, is a powerful solvent of earths and stones: but the alkali does also dissolve iron, especially when this is in a calcined or earthy state; and this solution is so much more compleat, as the fire is longer applied. Hence, in ordinary essays, where an alkaline salt is used, little or no regulus of iron is obtained. Now, glass acts upon, and dissolves earths and stones; but not, or very little, iron: consequently glass is the best flux for such essays: and experience confirms this assertion. If the ore contains but little iron, we may also add to the glass some borax; but borax cannot be employed singly, because it very soon fuses, and separates from the ore before the metal is revived. Quicklime is added, not only to absorb the sulphur and arsenic remaining in the ore, but also because it dissolves and vitrifies the stony and earthy matters of iron-ores, which are generally argillaceous. For which reason, in the large operations for smelting iron-ore, quicklime and even in certain cases gypsum are commonly added to facilitate the fusion.

The reduction of iron-ore, and even the fusion of iron, requires a violent and long-continued heat: therefore, in this operation, we must not employ an inflammable substance, as pitch, that is soon consumed, but charcoal pulverised, which in close vessels is not sensibly wasted. Too much charcoal must not be added, else it will prevent the action of the glass upon the earthy matter of the ore, and consequently the separation of the metallic part. Experiments have taught me, that

Mercury is never mineralised by arsenic. The richest mine of mercury is that of Almaden, in Spain. (*q*)

that one part of charcoal-dust to eight parts of ore was the best proportion.

When iron is surrounded by charcoal, it is not decomposed or destroyed: hence the iron of the ore, which sinks into the hollow made of paste of charcoal-dust and clay, remains there unhurt. The clay is added in this paste to render it more compact, and to keep the fluid iron collected together.

The air is directed betwixt the crucibles; because if it was thrown directly upon them, they would scarcely be able to resist the heat. The space betwixt the air-pipe and the crucibles ought to be constantly filled with charcoal, to prevent the cold air from touching the crucibles. Ductile and malleable iron is seldom obtained in this first operation. The sulphur and arsenic, and frequently also an earthy matter adhering to the iron, prevent these qualities.

(*q*) ORES *of* MERCURY. Besides the ores of mercury enumerated by the author of the Dictionary, Linnæus and Cronstedt mention a singular ore, in which the mercury is *mineralised by sulphur and by copper*. It is said to be of a blackish-grey color, of a glassy texture, and brittle. When the mercury and sulphur are expelled by fire, the copper is discovered by giving an opake red color to glass of borax, which, by continuance and encrease of heat, becomes green and transparent. *See* CINNABAR.

Cramer directs, that *ores of mercury should be essayed* by the following Processes:

PROCESS I.

[*Cramer's Art of Assaying, Proc.* 58.]

" *To separate Mercury out of an unsulphureous " Ore by Distillation.*

" TAKE a lump of the pulverised ore, " one common pound, which must stand for " one centner: put it into a glass retort " perfectly clean, well loricated, or coated " up to half the length of its neck: this must " be very long, and turned backwards with " such a declivity, that a glass recipient may " be perpendicularly applied to it: but you " must chuse a retort small enough, that " the belly of it may be filled hardly two-" thirds with the ore: this retort must be " placed so, that nothing of the fluid ad-" herent to the neck of it may fall into the " cavity of the belly, but that the whole may " run forward into the recipient. Finally, " have a small recipient full of cold water: " let it be perpendicularly situated, and " receive the neck of the retort in such " manner that the extremity of it be hardly " one half-inch immersed into the water.

" Let the retort be surrounded with hot " burning coals placed at some distance in " form of a circle, lest the vessel should burst " by too sudden a heat: then by degrees " bring the burning coals nearer and nearer, " and at last surround the whole retort with " them and with fresh charcoal, that it may " grow slightly red-hot: this fire having " been continued for an hour, let the retort " cool of itself: then strike the neck of it " gently, that the large drops which are al-" ways adherent to it may fall into the reci-" pient: let the recipient be taken away, and " the water separated from the mercury by " filtration, and let the mercury be weighed. " This operation may be more conveniently " performed in a sand bath, in which case " the pot containing the sand must be " middling red-hot, and the retort be able " to touch the bottom of it immediately; " nor is it then necessary that the retort be " loricated."

PROCESS II.

[*Cramer's Art of Assaying, Proc.* 59.]

" *To revive Mercury from a sulphureous Cin-" nabar-ore.*

" BEAT your ore extremely fine, and mix " it exactly with an equal portion of iron-" filings, not rusty; and proceed to distill it " with the same apparatus as in the former " Process; but urge it with the strongest fire " that can be made.

" Cinnabar may be separated from stones " by sublimation thus: Beat it to a fine " powder, and put it into a small, narrow " glass or earthen cucurbit, the belly of " which it must not fill more than one-" third part: stop the orifice at top; this " must

DXVIII. ORE *of the* REGULUS *of* ANTIMONY, *or* ANTIMONY. Native regulus of antimony was first observed by Mr. Swab, in Sweden, in the mine of Salberg, and described by him in the Memoirs of the Swedish Academy in 1749. Mr. Wallerius mentions it in his Mineralogy.

Regulus of antimony is generally united with sulphur, with which it forms antimony, which ought to be considered as a true ore of the regulus of antimony.

Another ore of regulus of antimony is also known, of a red color, in which the regulus is mineralised both by arsenic and by sulphur. This ore resembles some iron ores, and some kinds of blend. It is distinguished by its great fusibility, which is such, that it may be easily melted by the flame of a candle. (r)

" must be very narrow, to hinder the free " action of the air. Put this small cucurbit " in an earthen pot above two inches wide " in diameter, and gather sand around this " pot about as high as the pulverised ore " rises in the cucurbit. Then put it upon " burning coals in such manner that the bot- " tom of the pot may be middling red-hot. " Thus will your cinnabar ascend and form " a solid ponderous ring, which must be got " out by breaking the vessel."

(r) ORES *of* REGULUS *of* ANTIMONY. 1. The *native regulus* of antimony, observed by Mr. Von Swab, is said by that author to have differed from the regulus of antimony obtained from ores, in these two properties, that it was capable of being easily amalgamated with mercury, and that its calx shot into crystals during the cooling.

Besides the ores of regulus of antimony enumerated in the Dictionary, this semimetal is also found in ores of other metallic substances, as in the *plumose silver-ore*, and in the *stibiated lead-ore*. *See* ORES *of* SILVER *and of* LEAD.

The *ores of antimony may be essayed* by the following processes described by Mr. Cramer.

PROCESS I.

[Cramer's Art of Assaying, Process lx.]

" *To obtain antimony from its ore.*

" CHUSE a melting crucible or an " earthen pot not glaz'd that may contain " some common pounds of the ore of an- " timony, broken into small bits. Bore at " the bottom of the crucible some small holes, " two lines in diameter. Let the bottom of " the vessel be received by the orifice of a " smaller one, upon which it must be put; " and when the ore is put into it, let it be " covered with a tile, and all the joints be " stopt with lute.

" Put these vessels upon the pavement of " a hearth, and put stones all round them at " the distance of six inches. Fill this inter- " mediate space with ashes, so high that " the inferior pot be covered to the upper " brim. Then put fresh and burning coals " upon it, and with a pair of hand-bellows " excite the fire, till the upper vessel grows " red-hot: take off the fire a quarter of an " hour after, and when the vessels are grown " cold, open them. You will find that the " melted antimony has run through the holes " made at the bottom of the upper vessel " into the inferior one, where it is col- " lected.

PROCESS II.

[Cramer's Art of Assaying, Proc. lxi.]

" *To roast crude antimony, or its ore, with or* " *without addition.*

" CHUSE an earthen, flat, low dish, not " glaz'd, and if it cannot bear being made " middling red-hot, cover it over with a " coat of lute without. Spread it thinly over " with crude antimony, or with its ore, " beaten to a pretty coarse powder, not ex- " ceeding a few ounces at once. Put the " dish upon a fire-pan, having a few burn- " ing coals in it: increase the fire till it be- " gins to smoke a little. Meanwhile you

" must

DXIX. ORES *of* BISMUTH. Bismuth is chiefly mineralised by arsenic, and generally it is united with other ores, particularly with that of cobalt. (*s*)

" must incessantly move the powder with a " piece of new tobacco-pipe; for this causes " the sulphur to evaporate the sooner. If " you encrease the fire a little too soon, the " powder immediately gathers into large " clots, or even begins to melt. When this " happens, take it immediately off the fire " before it melts entirely. Then pulverise " it again, and finally make a gentle fire under it. Your black shining powder will " assume an ash-color almost like that of " earth, and become more refractory in the " fire; wherefore you may then encrease the " fire till your powder grows middling red-hot, and let it last till it ceases to smoke. " If you add to your crude antimony pulverised, half or an equal quantity of charcoal " dust, and perform the rest as above, the " roasting will be done more conveniently: " for it does not gather so easily into clots, " and melts with much greater difficulty. " When part of the sulphur is evaporated, " add some fat to it at several times. Thus " you will sooner finish the operation, and " the remaining calx will not be burnt to " excess. However, if it be thus exposed to " too violent and long-lasting a fire, a great " quantity of it evaporates; nor does it " cease entirely to smoak in a great fire. " And it will be enough, if growing middling red-hot, it does no longer emit the " unpleasant smell of the acid of sulphur."

PROCESS III.

[Cramer, *Proc.* lxii.]

"*To reduce a calx of antimony into a semimetallic " regulus.*

" MIX some calx of antimony with a quarter part of the black flux, and put it into " the crucible. Cover the vessel with a tile; " make the fire as quickly as the vessel can " bear it, but not greater than is necessary " to melt the flux. When the whole has been " well in fusion for half a quarter of an hour " (which may be tried with a tobacco-pipe, " taking off the tile) pour it into the melting " cone, which must be warm and done over " with tallow. Then immediately strike " the cone several times. You will find, " when the cone is inverted, a regulus, above " which is a saline scoria."

The methods of *calcining antimony by means of nitre*; of obtaining a *regulus of antimony* without a previous calcination or roasting, by throwing a mixture of powdered antimony, tartar, and nitre into a red-hot crucible, and by fusing this mixture; and of obtaining a *martial regulus of antimony*; are described at the articles of the Dictionary, ANTIMONY, *and* REGULUS *of* ANTIMONY.

(*s*) ORES *of* BISMUTH. I. Bismuth is found *native*, resembling the regulus of bismuth. II. An *ochre* of bismuth, of a whitish yellow color, is mentioned by Cronstedt, and is different from the ore improperly called *flowers of bismuth*, which is a calx of cobalt. III. Bismuth is mineralised; 1. By *sulphur*. This ore has the appearance of galena. 2. With *sulphurated iron*. Bismuth is found also in cobalts (*see* COBALT), and in some ores of silver.

Ores of Bismuth may be *essayed* by the following process.

PROCESS I.

[Cramer, Proc. lxiv.]

" *To melt bismuth from its ore.*

" BISMUTH ore may be melted with the " same apparatus as was directed for the " fusion of crude antimony out of its ore. " [*See* ORES *of* ANTIMONY.] Or you may " beat your ore to a very fine powder, with " the black flux, sandiver, and common salt, " in a close vessel, like the ore of lead, or " of tin, and melt it in a middling fire, " having a draught of air. But as this semimetal is destructible and volatile, you must " as quick as possible apply to it that degree " of fire which the flux requires to be " melted; and so soon as it is well melted, " the vessel must be taken out of the fire; " and when it is grown quite cold and broken, you will find your regulus."

Mr. Gellert directs that ores of bismuth should be essayed by fusing a quintal of pulverised ore with half a quintal of calcined

DXX. ORES *of the* REGULUS *of* COBALT, *or* COBALT. Cobalt is a grey-colored mineral, with more or leſs of a metallic appearance. Its grain is cloſe; it is compact and heavy, and frequently covered with an eﬄoreſcence of peach-colored flowers. Of this ſeveral kinds are known. All the true cobalts contain the ſemimetal called *regulus of cobalt*, the calx of which becomes blue by vitrification. This regulus is mineraliſed in cobalt by ſulphur, and eſpecially by a large quantity of arſenic. Some cobalts alſo contain biſmuth and ſilver.

Authors have given the name of cobalt to many minerals, although they do not contain the ſemimetal above-mentioned, but only becauſe they externally reſemble the ore of the regulus of cobalt. But theſe minerals can only be conſidered as falſe cobalts. They are diſtinguiſhable from true cobalt by trying whether they can yield the blue glaſs called ſmalt, and the ſympathetic ink. The red eﬄoreſcence is alſo a mark by which true cobalt is diſtinguiſhable from the falſe: but this eﬄoreſcence only happens when the ore has been expoſed to a moiſt air.

The principal mines of cobalt are in Saxony, where they are dug for the ſake of obtaining zaffre, azure-blue, or ſmalt, and arſenic. Very fine cobalt is alſo found in the Pyrenean mountains.

Cobalt is heavier than moſt other ores, from the large quantity of arſenic it contains; and in this reſpect it reſembles the ore of tin. (*t*)

DXXI. ORES *of* ZINC. The proper ore of zinc is a ſubſtance which has rather an earthy or ſtoney than metallic appearance, and is called *calamy*, *calamine*, or *lapis calaminaris*. This ſtone, although metallic, is but moderately heavy, and has not the brilliancy of moſt other ores. Its color is yellow, and like that of ruſt. It is alſo leſs denſe than other metallic minerals. It ſeems to be an ore naturally decompoſed. The calamine is not worked directly to obtain zinc from it, becauſe this would only ſucceed in cloſe veſſels, and conſequently with ſmall quantities, according to Mr. Margraaf's proceſs. But it is ſucceſsfully employed for the converſion of copper into braſs by cementation, by which the exiſtence of zinc in that ſtone is ſufficiently proved.

Mr. Wallerius enumerates alſo amongſt the ores of zinc a very compounded mineral, conſiſting of zinc, ſulphur, iron, and arſenic. This mineral called *blend* reſembles externally the ore of lead, and hence has been called *falſe galena*. Theſe blends have different forms and colors, but are chiefly red, like the red ore of antimony.

Zinc is obtained from certain minerals in the Eaſt Indies, of which we know little. (*u*)

borax, and half a quintal of pulveriſed glaſs, in order to vitrify the adherent earths and ſtones which invelop the biſmuth. But probably the heat requiſite for this vitrification would volatiliſe part of the biſmuth.

If the ore be of the kinds above deſcribed, mineraliſed by ſulphur, or by ſulphur and iron, a previous roaſting would be expedient, which may be performed in the ſame manner as is directed for the roaſting of antimony.

(*t*) The ores of cobalt are enumerated in a note under the article COBALT. The *eſſay* of cobalt is deſcribed at the article REGULUS *of* COBALT.

(*u*) ORES *of* ZINC. I. *Calciform ores* of zinc, according to Cronſtedt, are pure or mixed. The pure are indurated, and ſometimes cryſtalliſed, reſembling lead-ſpar. The mixed

DXXII. ORES *of* ARSENIC. The minerals which contain the largest quantity of arsenic are cobalts and white pyrites, although it is also contained in other ores, it being one of the mineralising substances. But as cobalt must be roasted to obtain the sulphur it contains, the arsenic also which rises during this torrefaction is collected, as we shall see in the article SMELTING *of* ORES, *and the particular articles of each of the metallic substances mentioned in this article.* (*x*)

mixed ore contains also some calx of iron. This is *calamine*. It is whitish, yellowish, reddish, or brown. II. Zinc is *mineralised*, 1. By *sulphurated iron*. *Ore of zinc*. Wallerius says, lead is sometimes contained in this ore. It is white, blue, or brown. 2. By *sulphur, arsenic, and iron*. *Blend*, or *pseudo-galena* or *false-galena*, or *black-jack*. See FALSE-GALENA. These are of various colors, white, yellowish, brown, reddish, greenish, black. They consist of scales, or are tessellated. Mr. Cronstedt thinks, that in blends the zinc is mineralised in the state of a calx, and in the ore of zinc, in its metallic state.

Although the minerals above enumerated have been known, from their property of converting copper into brass, to be ores of zinc, yet the method of essaying them so as to obtain the contained zinc was not known, or at least not published, before Mr. Margraaf's Memoir of the Berlin Academy for the year 1746, upon that subject. That very able chemist has shewn that zinc may be obtained from its ores, from the flowers, or from any other calx of zinc, by treating these with charcoal dust, in close vessels, to prevent the combustion of the zinc, which happens immediately upon its reduction, when exposed to air. For this purpose, he put a quantity of finely powdered calamine, or roasted blend, or other calx of zinc, well mixed with an eighth part of charcoal-dust, into a strong, luted earthen retort, to which he fitted a receiver. Having placed his retort in a furnace and raised the fire, he applied a violent heat during two hours. When the vessels were cold, and broken, he found the zinc in its metallic form adhering to the neck of the retort.

The chief difficulty in this operation is to get an earthen retort sufficiently compact to retain the vapor of the zinc, (for it easily pervades the Hessian crucibles, Stourbridge melting-pots, and similar vessels, as may be seen from the quantity of flowers which appear upon their outer surface, when zinc or its calxes and any inflammable matter have been exposed to heat within these vessels) and at the same time sufficiently strong to resist the violent fire which Mr. Margraaf requires.

A pretty exact essay of an ore of zinc may be made in the following manner.

Mix a quantity of pulverized roasted ore or calx of zinc with an eighth part of charcoal-dust. Put this mixture into a crucible capable of containing thrice the quantity. Diffuse equally amongst this mixture a quantity of small grains or thin plates of copper equal to that of the calamine or ore employed, and upon the whole lay another equal quantity of grains or plates of copper; and lastly, cover this latter portion of copper with charcoal-dust. Lute a lid upon the crucible; and apply a red heat during an hour or two. The copper or part of it will unite with the vapor of the zinc, and be thereby converted into brass. By comparing the weight of all the metal after the operation with the weight of the copper employed; the weight acquired, and consequently the quantity of zinc united with the copper, will be known. The copper which has not been converted into brass, or more copper with fresh charcoal-dust, may be again added in the same manner to the remaining ore, and the operation repeated with a heat somewhat more intense, that any zinc remaining in the ore may be thus extracted. A curious circumstance is, that a much greater heat is required to obtain zinc from its ore, by distillation, than in the operation, now described, of making brass; in which the separation of the zinc from its ore seems to be facilitated by its disposition to unite with copper.

(*x*) ORES *of* ARSENIC. I. Regulus of arsenic is found *native*. It is of a leaden color; it burns with a small flame; and is dissipated, leaving generally a very small quantity of calx of bismuth, or of calx of cobalt, and a very little silver. When it is of a solid and testaceous

DXXIII. OSTEOCOLLA. (y)

testaceous texture, it has been improperly called *testaceous cobalt*, in German, *scherben-cobolt*. II. Calx of arsenic is found in form of powder: *native flowers of arsenic*; or of indurated semitransparent crystals; *native crystalline arsenic*. III. Calx of arsenic is mixed, 1. With *sulphur*: when yellow, it is called *orpiment*; when red, it is called *native realgar*: the difference of color depends on the proportion of the two component parts. 2. With *calx of tin*; *tin-grains*. 3. With sulphur and silver, in the *red silver-ore*. 4. With *calx of lead*, in the *lead-spar*. 5. With calx of cobalt, in the *efflorescence of cobalt*. IV. Arsenic is *mineralised*; 1. With *sulphurated iron*; *arsenical pyrites*. 2. With *iron* only; *white pyrites*, or *misspickel*. 3. With *cobalt*, in all almost cobalt-ores. 4. With *silver*. See Ores *of* Silver. 5. With *copper*. See Ores *of* Copper. 6. With *antimony*. See Ores *of* Antimony. *Cronstedt*.

Arsenic may be separated from its ore or earthy matters, with which it happens to be mixed, *by sublimation*, according to the following process of Mr. Cramer. [Art of Assaying, Proc. lxix.]

"DO every thing as was said about mercury, or sulphur; but let the vessel which is put into the fire with the ore in it be of earth or stone, and the recipient be of glass, and of a middling capacity. Nor is it necessary that this should be filled with water, so it be but well luted. The fire must likewise be stronger, and continued longer than for the extracting of sulphur. Nevertheless every kind of arsenic cannot be extracted in a confined fire: for it adheres to the matrix more strongly than sulphur and mercury. You will find in the part of the vessel which is more remote from the fire, pulverulent and subtle flowers of arsenic; but there will adhere to the posterior part of the neck of the retort small solid masses, shining like small crystals, transparent, sometimes gathered into a solid sublimate, and perfectly white, if the ore of the arsenic was perfectly pure; which, nevertheless, happens very seldom. The flowers are most commonly thin, and of a grey color: which proceeds from the phlogiston mixt with the mass. They are often of a citron or of a golden color, which is a sign that there is in the mixture some mineral sulphur; and if the sublimate be red or yellow, it is a sign of much sulphur.

"As all the arsenic contained in the ore is not expelled in close vessels, you must weigh the residuum; then roast it in a crucible till it smoaks no longer, or rather in an earthen flat vessel not glazed, and in a strong fire to be stirred now and then with a poker, and then weigh it when grown cold: you will be able thus to know how much arsenic remained in the close vessel; unless the ore contain bismuth."

If the arsenic be sulphurated, it may be purified by triturating it with mercury or with fixed alkali, and by subliming the arsenic from the remaining sulphurated mercury or alkali. *See* Arsenic. The method of obtaining a regulus of arsenic is described at the article Regulus *of* Arsenic.

(y) Osteocolla is a substance formed by stoney matters filling up the interstices of rotten roots of trees. It has been particularly described by Mr. Gleditsch, and examined chemically by Mr. Margraaf. See Memoirs of the Berlin Academy for the Year 1748. The former author relates, that it is dug from grounds containing fine sand and a fine calcareous earth; and that sometimes the roots of living trees had been found converted into this stoney substance. From Mr. Margraaf's experiments we find, that the osteocolla examined by him was composed of a fine sand, a fine calcareous earth, and some rotten remains of a root. Neuman also says, that he found marine acid in osteocolla. But nothing of that or any other acid could be discovered by Margraaf. Neuman also says, that he totally dissolved osteocolla by means of dilute vitriolic acid. Hence the substances examined by these two chemists seem to have been different. Differences must arise from the different qualities of the soil in which osteocolla is found.

P.

DXXIV. PANACEA (MERCURIAL). This name, which ſignifies *univerſal remedy*, is given to a preparation of mercury much employed in the cure of thoſe diſeaſes, againſt which that metallic ſubſtance is effectual. To make the panacea, ſweet mercury is to be taken and ſublimed nine times, then reduced to a fine powder, and digeſted in good ſpirit of wine, which is, laſtly, to be diſtilled off, or only decanted.

Sweet mercury is corroſive ſublimate entirely ſaturated with mercury, and thrice ſublimed. Corroſive ſublimate is rendered milder by the operations which change it into ſweet mercury, and retains nothing of its cauſticity but a purgative quality; but by the nine ſublimations which change ſweet mercury into the panacea, the ſaline qualities of this mercurial preparation are ſo diminiſhed, that after all theſe ſublimations it has not even a purgative virtue.

Theſe changes are probably produced, becauſe at each ſublimation a ſmall quantity of marine acid is ſeparated; ſo that the panacea contains but very little of this acid, and is little elſe than very pure mercury, united with that quantity only of marine acid, which is neceſſary to deprive it of its fluid metallic form, and to give it a ſaline appearance.

The panacea therefore taken internally produces only the effects of mercury much divided, and in ſuch a ſtate that its molecules may be divided more and more by the action of the veſſels and liquors of the body, without being capable of uniting again ſo as to form fluid mercury. This remedy is therefore very proper for exciting ſalivations, and produces nearly the ſame effects as mercury adminiſtered by friction and fumigation.

We may employ the panacea with ſucceſs in venereal diſeaſes, and in others in which preparations of mercury are ſuitable. It may be given conveniently in pills or in a bolus, mixed with proper ſubſtances, and cannot be given in any other manner, becauſe it is inſoluble, and is very heavy. The doſe of it is from ſix to twenty-four grains, and even more in ſome circumſtances. *See the article* MERCURY, *for the medicinal uſes of this preparation.*

DXXV. PARTING. Parting is an operation by which gold and silver are separated from each other. As these two metals resist equally well the action of fire and of lead, they must therefore be separated by other methods. This separation could not be effected, if they were not soluble by different menstruums.

Nitrous acid, marine acid, and sulphur, which cannot dissolve gold, attack silver very easily; and therefore these three agents furnish methods of separating silver from gold, or of the operation called *parting*.

Parting by nitrous acid is the most convenient, and therefore most used, and even almost the only one employed by goldsmiths and coiners. Wherefore it is called simply *parting*. That made with the marine acid is only made by cementation, and is known by the name of *concentrated parting*. Lastly, parting by sulphur is made by fusion, which the chemists call the *dry way*, and is therefore called *dry parting*. We shall describe each of these methods.

DXXVI. PARTING *by* AQUA FORTIS. Although parting by aqua fortis be easy, as we have said, it cannot however succeed, or be very exact, unless we attend to some essential circumstances.

1. The gold and silver must be in a proper proportion; for if the gold was in too great quantity, the silver would be covered and guarded by it from the action of the acid.

Therefore when essayers do not know the proportion of these two metals in the mass to be operated upon, they discover it by the following method.

They have a certain number of needles composed of gold and silver allayed together in graduated proportions, and the allay of each needle is known by a mark upon it. These are called *proof-needles*.

When essayers want to know nearly the proportion of gold and silver in a mass, they rub this mass upon a touchstone, so as to leave a mark upon it. They then make marks upon the touch-stone with some of the needles the color of which they think comes nearest to that of the mass. By comparing the marks of these needles with the mark of the mass, they discover nearly the proportion of the gold and silver in the mass.

If this trial shews that in any given mass the silver is not to the gold as three to one, this mass is improper for the operation of parting by aqua fortis. In this case, the quantity of silver necessary to make an allay of that proportion must be added.

This operation is called *quartation*, probably because it reduces the gold to a fourth part of the whole mass.

2. That the parting may be exact, the nitrous acid or aqua fortis employed must be very pure, and especially free from mixture of vitriolic and marine acids. Its purity must therefore be ascertained, and if this be found not sufficient, the acid must be purified by an operation called the *precipitation of* AQUA FORTIS. *See that article.*

If the purity of the aqua fortis was not attended to, a quantity of silver proportionable to these two foreign acids would be separated during the solution; and this portion of silver, reduced by these acids to vitriol of silver and to luna cornea, would remain mingled with the gold, which consequently would not be entirely purified by the operation.

When the metallic mafs is properly allayed, it is to be reduced to plates, rolled up fpirally, called cornets; or to grains. Thefe are to be put into a matrafs, and upon them a quantity of aqua fortis is to be poured, the weight of which is to that of the filver as three to two: and as the nitrous acid employed for this operation is rather weak, the folution is affifted, efpecially at firft, by the heat of a fand-bath, in which the matrafs is to be placed. When, notwithftanding the heat, no further mark of folution appears, the aqua fortis charged with filver is to be decanted. Frefh nitrous acid is to be poured into the matrafs, ftronger than the former, and in lefs quantity, which muft be boiled on the refiduous mafs, and decanted as the former. Aqua fortis muft even be boiled a third time on the remaining gold, that all the filver may be certainly diffolved. The gold is then to be wafhed with boiling water. This gold is very pure, if the operation has been performed with due attention. It is called *gold of parting.*

No addition of filver is required, if the quantity of filver of the mafs is evidently much more confiderable than that of the gold: perfons who have not proof needles, and other apparatus to determine the proportion of the allay, may add to the gold an indeterminate quantity of filver, obferving that this quantity be rather too great than too fmall, and fo confiderable as to render the mafs nearly as white as filver; for a large quantity of filver is rather favorable than hurtful to the operation: It has no other inconvenience than an ufelefs expence, as the larger the quantity is of filver, the more aqua fortis muft be employed. We ought to attend to this fact, that the color of gold is fcarcely perceptible in a mafs two-thirds of which is filver and one-third is gold; this color then muft be much lefs perceptible when the gold is only one-fourth part, or lefs, of the whole mafs.

If the quantity of gold exceeds that of the filver, the mafs may be expofed to the action of aqua regia, which would be a kind of inverfe parting, becaufe the gold is diffolved in that menftruum, and the filver is not, but rather reduced to a luna cornea, which remains in form of a precipitate after the operation. But this method is not much practifed, for the following reafons.

Firft, the gold cannot be eafily feparated from the aqua regia; for if the parting has been made with an aqua regia prepared with fal ammoniac, or if the gold be precipitated by a volatile alkali, this gold has a fulminating quality, and its reduction requires particular operations. If the aqua regia has been made with fpirit of falt, and the precipitation effected by a fixed alkali, the gold will not then be fulminating, but the precipitation will be very flow, and probably incompleat. *See* GOLD (FULMINATING).

Secondly, in the parting by aqua regia, the filver is indeed precipitated into a luna cornea, and thus feparated; but this feparation is not perfect, as a fmall quantity of luna cornea will always remain diffolved by the acids, if this folution even could be only effected by the fuperabundant water of thefe acids. Accordingly the filver is not fo accurately feparated from the gold by aqua regia, as the gold is from the filver by aqua fortis. We fhall afterwards fee, at the article PARTING (CONCENTRATED), that by this operation, filver may be feparated from gold without the neceffity of quartation, although thefe metals fhould not be in a proper proportion for the parting by aqua fortis.

The gold after the parting by aqua fortis is much more easily collected when it remains in small masses, than when it is reduced to a powder.

When the mass has been regularly quarted, that is, when it contains three parts of silver and one part of gold, we must employ, particularly for the first solution, an aqua fortis so weakened that heat is required to assist the solution of the silver: by which means the solution is made gently; and the gold which remains preserves the form of the small masses before the solution. If the aqua fortis employed were stronger, the parts of the gold would be disunited and reduced to the form of a powder, from the activity with which the solution would be made.

We may indeed part by aqua fortis a mass containing two parts of silver to one part of gold; but then the aqua fortis must be stronger; and if the solution be not too much hastened, the gold will more easily remain in masses after the operation. In both cases, the gold will be found to be tarnished and blackened, probably from the phlogiston of the nitrous acid. Its parts have no adhesion together, because the silver dissolved from it has left many interstices; and the cornets or grains of this gold will be easily broken, unless they be handled very carefully. To give them more solidity, they are generally put into a test under a muffle and made red-hot, during which operation they contract considerably, and their parts are approximated. These pieces of gold are then found to be rendered much more solid, so that they may be handled without being broken. By this operation also the gold resumes its color and lustre; and as it generally has the figure of cornets, it is called *gold in cornets*, or *grain gold*. Essayers avoid melting it, as they chuse to preserve this form, which shews that it has been parted.

The gold and silver thus operated upon ought to have been previously refined by lead, and freed from all allay of other metallic matters, so that the gold which remains should be as pure as is possible. However, as this is the only metal which resists the action of aqua fortis, it might be purified by parting from all other metallic substances; but this is not generally done for several reasons. First, because the refining by lead is more expeditious and convenient for the separation of the gold from the imperfect metals; and secondly, because the silver, when afterwards separated from the aqua fortis, is pure; lastly, because most imperfect metals do not remain completely and entirely dissolved in nitrous acid, from the portion of phlogiston which this acid deprives them of, the gold would be found after the parting mixed with the part of these metals which is precipitated.

The gold remaining after the parting ought to be well washed, to cleanse it from any of the solution of silver which might adhere to it; and for this purpose distilled water ought to be used, or at least water the purity of which has been ascertained by its not forming a precipitate with a solution of silver, because such a precipitate would alter the purity of the gold.

The silver dissolved in the aqua fortis may be separated either by distillation, in which case all the aqua fortis is recovered very pure, and fit for another parting; or it may be precipitated by some substance which has a greater affinity than this metal with nitrous acid. Copper is generally employed for this purpose at the mint.

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The ſolution of ſilver is put into copper veſſels. The aqua fortis diſſolves the copper, and the ſilver precipitates. When the ſilver is all precipitated, the new ſolution is decanted, which is then a ſolution of copper. The precipitate is to be well waſhed, and may be melted into an ingot. It is called *parted ſilver*. When this ſilver has been obtained from a maſs which had been refined by lead, and when it has been well waſhed from the ſolution of copper, it is very pure.

Mr. Cramer obſerves juſtly in his Treatiſe on Eſſaying, that however accurately the operation of parting has been performed, a ſmall portion of ſilver always remains united with the gold, if the parting has been made by aqua fortis; or a ſmall portion of the gold remains united with the ſilver, if the parting has been made by aqua regia; and he eſtimates this ſmall allay to be from a two hundredth to a hundredth and fiftieth part, which quantity may be conſidered as nothing for ordinary purpoſes, but may become ſenſible in accurate chemical experiments. (z)

(z) The maſs of gold and ſilver to be quarted, ought previouſly to be *granulated*, which may be done by melting it in a crucible, and pouring it into a large veſſel full of cold water, while at the ſame time a rapid circular motion is given to the water by quickly ſtirring it round with a ſtick or broom.

The veſſels generally uſed for this operation, called *parting-glaſſes*, have the form of truncated cones, the bottom being commonly about ſeven inches wide, the aperture about one or two inches wide, and the height about twelve inches. Theſe glaſs veſſels ought to have been well annealed, and choſen free from flaws; as one of the chief inconveniencies attending the operation is, that the glaſſes are apt to crack, by expoſure to cold, and even when touched by the hand. Some operators ſecure their glaſſes by a coating. For this purpoſe they ſpread a mixture of quicklime ſlaked with beer and whites of eggs upon linen cloth, which they wrap round the lower part of the veſſel, leaving the upper part uncovered, that they may ſee the progreſs of the operation; and over this cloth they apply a compoſition of clay and hair. Schlutter adviſes to put the parting-glaſſes in copper veſſels containing ſome water, and ſupported by trevets, with fire under them. When the heat communicated by the water is too great, it may be diminiſhed by adding cold water, which muſt be done very carefully by pouring againſt the ſides of the pan, to prevent too ſudden an application of cold to the parting-glaſs. The intention of this contrivance is, that the contents of the glaſſes, if theſe ſhould break, may be received by the copper veſſel. Into a glaſs fifteen inches high, and ten or twelve inches wide at bottom, placed in a copper-pan twelve inches wide at bottom, fifteen inches wide at top, and ten inches high, he uſually put about eighty ounces of metal, with twice as much aqua fortis.

The *aqua fortis* ought to be ſo ſtrong as to be capable of acting ſenſibly on ſilver when cold, but not ſo ſtrong as to act violently. If the aqua fortis be very ſtrong, however pure, and if the veſſels be well cloſed, a ſmall quantity of the gold will be diſſolved along with the ſilver, which is to be guarded againſt.

Little *heat* ought to be applied at the beginning, the liquor being apt to ſwell and riſe over the veſſel; but when the acid is nearly ſaturated, the heat may be ſafely encreaſed.

When the ſolution ceaſes, which may be known by the diſcontinuance of the effervеſcence, or emiſſion of air-bubbles, the liquor is to be poured off. If any grains appear entire, more aqua fortis muſt be added, that all the ſilver may be diſſolved. If the operation has been performed ſlowly, the remaining gold will have ſtill the form of diſtinct maſſes, which are to receive ſolidity and color by fire, in the manner directed by the author of the Dictionary. If the operation has been performed haſtily, the gold will have the appearance of a black mud or powder, which after five or ſix waſhings with pure water muſt be melted.

The *ſilver is uſually recovered* by precipitating it from the aqua fortis by means of copper-veſſels into which the liquor is poured,

DXXV. PARTING (CONCENTRATED). Concentrated parting is also called *parting by cementation*, because it is actually performed by cementation. This parting or purification of gold is used when the quantity of it is so great in proportion to the silver, that it cannot be separated by aqua fortis. This operation is done in the following manner.

A cement is first prepared composed of four parts of bricks powdered and sifted, of one part of green vitriol calcined till it becomes red, and of one part of common salt. The whole is very accurately mixed together, and a firm paste is made of it by moistening it with a little water or urine. This cement is called *cement royal*, because it is employed to purify gold, which is considered by chemists as the king of metals.

The gold to be cemented is to be reduced to plates as thin as small pieces of money. At the bottom of the crucible or cementing-pot, a stratum of cement, of the thickness of a finger, is to be put, which is to be covered with plates of gold; upon these another stratum of cement is to be laid; and then more plates of gold, till the crucible or pot is filled with these alternate strata of cement and of gold. The whole is then to be covered with a lid, which is to be luted with a mixture of clay and sand. This pot is to be placed in a furnace, or oven, and heated by degrees till it is moderately red, which heat is to be continued during 24 hours. The heat must not be so great as to melt the gold. The pot or crucible is then left to cool, and the gold is to be carefully separated from the cement, and boiled at different times in a large quantity of pure water. This gold is to be essayed upon a touchstone or otherwise; and if it be found not sufficiently purified, it is to be cemented a second time in the same manner.

The vitriolic acid of the bricks and of the calcined vitriol disengages the acid of the common salt during this cementation: and this latter acid dissolves the silver allayed with the gold, and separates it by that means.

This experiment proves, that although marine acid, while it is liquid, cannot attack silver, it is nevertheless a powerful solvent of that metal. But for this purpose it must be applied to the silver in the state of vapors, extremely concentrated, and assisted with a considerable heat. All these circumstances are united in the concentrated parting.

This experiment proves also, that notwithstanding all these circumstances, which favour the action of the marine acid, it is incapable of dissolving gold.

Lastly, the marine acid in this state more effectually dissolves the silver than the nitrous acid does in the parting by aqua fortis, since this operation succeeds

or of plates of copper which are thrown along with the liquor into glass-vessels. A considerable heat is required to accelerate this precipitation. Dr. Lewis says, he has observed that when the aqua fortis was perfectly saturated with silver, no precipitation was occasioned by plates of copper, till a drop or two of aqua fortis was added to the liquor, and then the precipitation began and continued as usual.

The precipitated silver must be well washed in boiling water, and fused with some nitre, the use of which is to scorify any cupreous particles, which may adhere to the silver.

From the solution of copper in aqua fortis, a blue pigment called *verditer* is obtained by precipitation with whiting. See VERDITER.

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well when the silver is in so small a proportion as that it would be protected from the action of the nitrous acid in the ordinary parting.

Instead of sea salt, nitre may be used with equal success; because the nitrous acid is then put in a state to attack the silver, notwithstanding the quantity of gold which covers it.

Several chemists and artists use both nitre and common salt in the cement royal; which shews that the acids of aqua regia, applied in this manner at the same time to gold and to silver, attack the latter metal preferably to the former. (a)

The gold must be very carefully washed after the operation to cleanse it from particles of dissolved silver, which otherwise would stick to it.

The silver may be separated from the cement by fusion with a sufficient quantity of lead and litharge, and by cupelling the lead which retains the silver. (b)

DXXVIII. PARTING (DRY). Dry parting, or parting by fusion, is performed by sulphur, which has the property of uniting easily with silver, while it does not attack gold.

This method of separating these two metals would be the cheapest, the most expeditious and convenient of any, if the sulphur could dissolve the silver, and separate it from the gold as well and as easily as nitrous acid does: but, on the contrary, we are obliged to employ particular treatment, and a kind of concentration, to begin the union of the sulphur with the silver allayed with gold. Then repeated and troublesome fusions must be made, in each of which we are obliged to add different intermediate substances, and particularly the metals which have the strongest affinity with sulphur, to assist the precipitation, which in that case does not give a regulus of pure gold, but a gold still allayed with much silver, and even with a part of the precipitating metals; so that, to compleat the operation, cupellation is necessary, and also parting by aqua fortis.

From what we have said concerning this operation we may perceive, that it ought not to be made but when the quantity of silver with which the gold is allayed is so great, that the quantity of gold which might be obtained by the ordinary parting is not sufficient to pay the expences; and that it is only proper for concentrating a larger quantity of gold in a smaller quantity of silver. As this dry parting is troublesome, and even expensive, it ought not to be undertaken but on a considerable quantity of silver allayed with gold. Accordingly, Cramer, Schlutter, Schindler, and all good chemists and artists who have given processes for the dry parting, recommend its use only in the above-mentioned cases. We wish that this operation could be improved: it would be much more advantageous, if it could be done by two or three fusions; and if by

(a) By this method some of the gold would probably be dissolved along with the silver. As no advantages are said to attend it, to give it preference to cementation with nitre or with sea-salt singly, Dr. Lewis does judiciously, I think, disapprove of it.

(b) Gold is never purified by one operation of this kind. It must therefore be again melted, beat into plates, and cemented as before. The operation is troublesome, and is now little used, excepting, as Dr. Lewis says, for extracting silver or base metals from the surface of gold, and thus giving to an alloyed metal the color and appearance of pure gold.

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theſe an exact ſeparation could be obtained of a ſmall quantity of gold mixed with a large quantity of ſilver. (c)

Under the article PURIFICATION *of* GOLD *by* ANTIMONY, we ſhall ſee that this purification is a true dry parting, and we ſhall there find the theory of what paſſes in that operation.

(c) As this operation for extracting a ſmall quantity of gold from a large quantity of ſilver is, notwithſtanding its inconveniences, approved by Schlutter, Scheffer, and other authors, and practiſed in Hartz, we ſhall add to the article in the Dictionary concerning it, what Dr. Lewis, in his excellent Hiſtory of Gold, has ſaid upon the ſubject.

The moſt advantageous method of ſeparating a ſmall portion of gold from a large one of ſilver appears to be by means of ſulphur, which unites with and ſcorifies the ſilver without affecting the gold: but as ſulphurated ſilver does not flow thin enough to ſuffer the ſmall particles of gold diffuſed through it to reunite and ſettle at the bottom, ſome addition is neceſſary for collecting and carrying them down.

In order to the commixture with the ſulphur, fifty or ſixty pounds of the mixed metal, or as much as a large crucible will receive, are melted at once, and reduced into grains by lading out the fluid matter, with a ſmall crucible made red-hot, and pouring it into cold water ſtirred with a rapid circular motion. From an eighth to a fifth of the granulated metal, according as it is richer or poorer in gold, is reſerved; and the reſt well mingled with an eighth of powdered ſulphur. The grains enveloped with the ſulphur are again put into the crucible, and the fire kept gentle for ſome time, that the ſilver, before it melts, may be thoroughly penetrated by the ſulphur; if the fire was haſtily urged, great part of the ſulphur would be diſſipated, without acting upon the metal.

If to ſulphurated ſilver in fuſion pure ſilver be added, the latter falls to the bottom, and forms there a diſtinct fluid, not miſcible with the other. The particles of gold, having no affinity with the ſulphurated ſilver, join themſelves to the pure ſilver, wherever they come in contact with it, and are thus transferred from the former into the latter, more or leſs perfectly according as the pure ſilver was more or leſs thoroughly diffuſed through the mixed. It is for this uſe that a part of the granulated metal was reſerved. The ſulphurated maſs being brought into perfect fuſion, and kept melted for near an hour in a cloſe covered crucible, one third of the reſerved grains is thrown in; and as ſoon as this is melted, the whole is well ſtirred, that the freſh ſilver may be diſtributed through the mixed, to collect the gold from it. The ſtirring is performed with a wooden rod; an iron one would be corroded by the ſulphur, ſo as to deprive the mixed of its due quantity of ſulphur, and likewiſe render the ſubſequent purification of the ſilver more troubleſome. The fuſion being continued an hour longer, another third of the unſulphurated grains is added, and an hour after this the remainder; after which the fuſion is further continued for ſome time, the matter being ſtirred at leaſt every half hour from the beginning to the end, and the crucible kept cloſely covered in the intervals.

The ſulphurated ſilver appears in fuſion of a dark brown color: after it has been kept melted for a certain time, a part of the ſulphur having eſcaped from the top, the ſurface becomes white, and ſome bright drops of ſilver, about the ſize of peas, are perceived on it. When this happens, which is commonly in about three hours after the laſt addition of the reſerved grains, ſooner or later according as the crucible has been more or leſs cloſely covered, and the matter more or leſs ſtirred, the fire muſt be immediately diſcontinued; for otherwiſe more and more of the ſilver, thus [illegible] ng its ſulphur, would ſubſide and [illegible] with the part at the bottom in whic[illegible] old is collected. The whole is p[illegible] out into an iron mortar greaſed and [illegible] or if the quantity is too large to [illegible] tably lifted at once, a part is firſt laded out from the top with a ſmall crucible, and the reſt poured into the mortar. The gold, diffuſed at firſt through the whole maſs, is now found collected into a part of it at the bottom, amounting only to about as much as

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DXXIX. P E L I C A N. A pelican is a glass alembic consisting of one piece. It has a tubulated capital, from which two opposite and crooked beaks pass out, and enter again into the belly of the cucurbit. This vessel has been contrived for a continued distillation and cohobation, which chemists call *circulation*. The volatile parts of substances put into this vessel rise into the capital, and are obliged to return through the crooked beaks into the cucurbit; and this without interruption, or luting and unluting the vessels.

Although the pelican seems to be a very convenient instrument, it is nevertheless little used, and even much neglected at present, either because the modern chemists have not so much patience as the ancient chemists had, for making long experiments; or because they find that two matrasses, the mouth of one of which is inserted into the mouth of the other, produce the same effect. *See Plate I.*

DXXX. P E L L I C L E. By this word chemists mean a very thin saline crust, which is formed upon the surface of solutions of salts, when they are evaporated to a certain degree. This pellicle is nothing else than a number of saline particles crystallized by evaporation at the surface of the liquor rather than any where else, because the evaporation is made there. These small crystals of salt at first cover the surface of the liquor, and give it a dusky ap-

was reserved unsulphurated. This part may be separated from the sulphurated silver above it by a chisel and hammer; or more perfectly, the surface of the lower mass being generally rugged and uneven, by placing the whole mass with its bottom upwards in a crucible: the sulphurated part quickly melts, leaving unmelted that which contains the gold, which may thus be completely separated from the other. The sulphurated silver is essayed, by keeping a portion of it in fusion in an open crucible, till the sulphur is dissipated, and then dissolving it in aqua fortis. If it should still be found to contain any gold, this is to be melted again, as much more unsulphurated silver is to be added as was employed in each of the former [illegible], and the fusion continued about an hour and a half.

The gold thus collected into a part of the silver may be further concentrated into a [illegible] [illegible]

of lead is at most forty pounds on a quintal or hundred pounds of the ore. The lead worked off on a test or concave hearth yields about a hundred and ten grains of silver, and the silver contains only a three hundred and eighty-fourth part of gold; yet this little quantity of gold, amounting scarcely to a third of a grain in a hundred weight of the ore, is thus collected with profit. The author above-mentioned confines this method of separation to such silver as is poor in gold, and reckons parting with aqua fortis more advantageous where the gold amounts to above a sixty-fourth of the silver; he advises also not to attempt concentrating the gold too far, as a portion of it will always be taken up again by the silver. Mr. Scheffer, however, relates (in the Swedish Memoirs for the year [illegible]) that he has by this method brought the gold to perfect fineness; and that he has likewise collected all the gold which the silver contained; the silver of the last operations, which had taken up a portion of the gold, being reserved to be worked over again with a fresh quantity of gold-holding silver. The sulphurated silver is purified by continuing it in fusion for some time with a large surface exposed to the air: the sulphur gradually exhales, and leaves the silver entire.

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pearance, as if it were covered with duſt or with a very thin ſkin, from which appearance the name of pellicle has been given.

As all cryſtallizable ſalts may be cryſtallized by evaporation alone, in the ſolution therefore of any of theſe ſalts a pellicle may be formed; and alſo, as all ſolutions of ſalts, evaporated till a pellicle is formed, furniſh cryſtals by expoſing the liquor to cold, chemiſts have eſtabliſhed a general rule for cryſtallization, to evaporate ſolutions of ſalts till a pellicle is formed, and then to leave them to cryſtallize by expoſure to cold.

This rule is applicable to many ſalts, but is not general; for ſome ſalts, as common ſalt, do not cryſtallize by expoſure to cold, although the ſolution of them has been previouſly evaporated till a pellicle has been formed; while other ſalts, as nitre and Glauber's ſalt, may be cryſtallized in great quantities, although their ſolutions have not been evaporated ſo much as that a pellicle has been formed. Hence, to cryſtallize ſuch ſalts as common ſalt, the evaporation muſt be continued after the pellicle has been formed; and to obtain fine cryſtals of nitre, Glauber's ſalt, and others which cryſtallize in a ſimilar manner, the evaporation muſt not be continued till a pellicle is formed, but their ſolutions muſt be left to cool ſlowly before it has been ſo much evaporated. *See* CRYSTALLIZATION *of* SALTS

DXXXI. PENNY-WEIGHTS. Penny-weights are fictitious parts into which we ſuppoſe any maſs of ſilver to be divided, to ſpecify its degree of purity.

Any maſs of ſilver, the purity of which is to be examined, is ſuppoſed to conſiſt of twelve equal parts called penny-weights; and if the ſilver be perfectly fine, and contain no allay, then the twelve parts of the maſs are all of pure ſilver, and this ſilver is ſaid to be *ſilver of twelve penny-weights*. If the maſs of ſilver contain a twelfth part of allay, it will then contain only eleven parts of pure ſilver, and it will be called *ſilver of eleven penny-weights*, &c.

To expoſe more preciſely the value of ſilver, each penny-weight is ſubdivided into twenty four grains. (*d*)

DXXXII. PEPPER. (*e*)

(*d*) A *penny-weight* is alſo a real weight uſed in the weighing of metals. It is equal to twenty-four real grains, and is the twentieth part of an ounce troy.

(*e*) PEPPER. Neuman ſays, that *Pimento*, or *Jamaica Pepper*, appears from a chemical examination to contain, 1. An indiſſoluble earth, exceeding in quantity all the other principles taken together, and amounting to five drams and a ſcruple in an ounce. 2. Gummy or mucilaginous matter, which is the ingredient next in quantity. An ounce treated with water at firſt gave two drams and two grains of gummy extract; and another ounce, freed by rectified ſpirit from all that the menſtruum could diſſolve, yielded ſtill with water five ſcruples of mucilage. 3. A reſinous ſubſtance in ſmaller quantity. The reſinous extract obtained by applying rectified ſpirit at firſt, amounted to only one dram and ſix grains from an ounce; an ounce freed from its mucilaginous matter by coction in water, yielded of pure reſin no more than one ſcruple. 4. An eſſential oil in ſtill ſmaller quantity; of this principle an ounce of pepper contains ſcarcely half a dram.

Upon examining the qualities of the ſeveral products, it appeared, that the oil is the principal and characteriſtic part, containing all the ſmell and the aromatic flavor, though not the pungency of the berry. As the prevailing flavor of pimento approaches that of cloves, the oil alſo greatly reſembles the genuine oil of cloves. It has the ſame kind of ſmell and taſte, diſcovers no great heat or pungency, and is ſo heavy as to ſink in water;

DXXXIII. PERUVIAN-BARK. (*f*)

DXXXIV. PETROLEUM. *See* Bitumen.

DXXXV. PETUNTSE. (*g*)

DXXXV. PHLEGM.

Chemiſts have given the name *Phlegm* to the moſt watery part obtained from bodies by diſtillation or otherwiſe.

Phlegm is frequently water mixed ſuperabundantly, and not combined in the bodies from which it is obtained. Such are the phlegms obtained by diſ-

water: to which may be added, that the oil of pimento, like that of cloves, reſides chiefly in the ſhell or cortical part, the internal ſubſtance yielding little or none. 2. That the heat and pungency are lodged in the reſin. In this reſpect alſo pimento agrees with cloves: but as pimento in ſubſtance is far leſs hot and fiery than cloves, its reſin is alſo more mild. 3. That the gummy parts have very little activity.

Rectified ſpirit of wine elevates nothing from this ſpice in diſtillation, the oil of pimento being too ponderous to riſe with ſo light a fluid. The only way of making a ſpirit from it is to diſſolve ſome of the oil in pure ſpirit of wine. An agreeable ſpirituous water may be made with proof ſpirit, the watery phlegm in that liquor carrying up a part of the oil.

The *black pepper* of the Eaſt Indies contains an eſſential oil which has a ſtrong and durable ſmell, and a taſte the mildeſt of all eſſential oils. This oil is partly elevated in diſtillation by rectified ſpirit of wine; which thereby acquires the flavor, but none of the pungency, of the pepper. The ſpirituous extract is exceſſively fiery. The watery extract is alſo very hot and biting. Neither this menſtruum nor the ſpirit can, ſingly, extract all the hot matter of the pepper.

Sixteen ounces of black pepper yielded with water ten ounces of gummy extract, and afterwards with rectified ſpirit three drams of reſin: another pound, treated firſt with ſpirit, gave two ounces and two drams of reſinous extract; and afterwards, with water, ſeven ounces four drams and two ſcruples of gummy matter. This laſt extract had ſtill ſome degree of pungency, rectified ſpirit ſeeming not to take up all the active parts, any more than water. Of eſſential oil, about two drams and a half may be obtained from a pound.

White pepper has the ſame kind of taſte and flavor as the black, but in a much leſs degree. It agrees alſo with the black in the nature of its chemical principles; and is, in effect, the ſame kind of fruit gathered before it is grown fully ripe, and freed from the outer ſkin. *Neuman.*

(*f*) Peruvian Bark. Neuman ſays, that from a pound of Peruvian bark rectified ſpirit extracted ten drams and two ſcruples of reſinous matter; and that water extracted from the reſiduum five drams of gummy matter. He ſays alſo, that by applying water firſt, and afterwards ſpirit, to the reſiduum, ſeven drams and a ſcruple of gummy matter, and ſix drams of reſinous matter were extracted. To this Dr. Lewis adds the following note. *See* his edition of *Neuman's Works*.

"Different ſorts of Peruvian bark differ conſiderably in their yield of extract. Thoſe which I examined afforded a much larger quantity of reſinous extract than Neuman obtained from his.

"It is obſervable of this drug, ſays he, that its aſtringency reſides wholly in the reſin, which does not appear to be in any degree ſoluble in watery liquors, but its bitterneſs in a gummy-reſinous ſubſtance, or ſuch a one as is ſoluble both in water or in ſpirit. Both principles may be extracted by boiling in water, the reſin melting out by the heat, and rendering the liquor turbid. The decoction in this ſtate taſtes aſtringent as well as bitter; but on ſtanding it depoſites the reſin and becomes clear, and then proves ſimply bitter. Repeated coction and large quantities of water are neceſſary for extracting all the virtues of the bark: the reſin melts out in the firſt boilings: the decoctions made afterwards are tranſparent and bitter, without the leaſt turbidneſs or aſtringency."

(*g*) Petuntse. This is the Chineſe name given to a ſtone which is one of the ingredients of oriental porcelain. It is ſaid to be white, fuſible by fire, to give phoſphoric light when rubbed, and to have the other properties of the ſtones called fluors. *See* Porcelain.

tillation with the heat of a water-bath, from all those vegetable and animal matters which contain no principle so volatile as to rise with a less heat than that of boiling water. These phlegms, which are produced merely by drying, are nothing but water almost pure, that is, the water of vegetation: but a phlegm consisting of water which had been combined in any body, as, for instance, the phlegm obtained in the distillation of oils, is far from being a pure water. It is still mixed and even united with a sensible quantity of the principles of the body, and requires further operations, and chiefly the assistance of intermediate substances, to separate it perfectly.

Neither is that phlegm pure water, which, though it is superabundant, yet adheres to certain substances, especially to those that are volatile. Such are liquid volatile alkalis, and most alkalis. By distillation we may separate a considerable quantity of their phlegm or superabundant water, which operation is called *dephlegmation:* but this phlegm contains always a certain quantity of the saline matters with which it was originally mixed.

Hence we may see that the word *Phlegm* signifies in general the most watery part separated from several bodies, but that it is rarely pure water; and that phlegms differ from each other according to the nature of the substances from which they are obtained.

DXXXVI. PHLOGISTON. By *phlogiston* chemists mean the most pure and simple inflammable principle.

Amongst the various natural bodies, some have been observed to be capable, by exposure to fire with the concurrence of air, of being kindled, of producing flame, of augmenting the fire, and of maintaining and supporting it; while other bodies, by exposure to fire, do indeed become hot, red, and luminous; but are incapable of producing flame, or of maintaining fire. These latter substances do not burn, but only are penetrated by a foreign fire, and cease to be hot and luminous, when this extraneous fire is removed from them.

These bodies are distinguished from each other by calling the former *combustible bodies*, and the latter *incombustible*. Chemists have always made a great distinction betwixt these two kinds of bodies, and have perceived that the inflammability of the former was caused by a principle which did not exist in the latter: but as this inflammable principle cannot be separated from the other principles of bodies, nor be obtained pure; and, consequently, as it is impossible to discover all the properties which are peculiar to it, and which distinguish it from all other substances, the ancient chemists had very confused notions of this inflammable principle; and even now, notwithstanding all the sagacity of the greatest modern chemists, this is, of all the principles of bodies, the least accurately known.

The great error of ancient chemists was, in not sufficiently distinguishing this principle from other more compound bodies, which indeed contain much of it, but of which it is only a constituent part. For instance, they confounded it with oil and with sulphur, the names of which substances were indiscriminately given to it, although neither oil nor sulphur be the phlogiston of the moderns, but are only substances into the composition of which a great quantity of this principle enters.

On the other hand, as oil, sulphur, and other inflammable matters, differ so much from each other that they cannot be considered as the same thing, pro-

bably the ancients, who sometimes gave it one and sometimes another of the names of these inflammable compounds, mistook its unity and identity; that is, they did not know that one only inflammable principle exists, always the same, always similar to itself, either in oils, or in sulphur, or in coals, in a word, in any combustible whatever. We owe the knowledge of these important truths to modern chemists, and particularly to the illustrious Stahl, who has created in some measure a new chemistry, and entirely changed the appearance of this science. All that we shall say concerning phlogiston or fire as a principle of bodies shall be the grounds of the doctrine of that chemist concerning this important matter. To that we shall only add some observations resulting from an attentive examination of the phenomena.

Phlogiston ought to be considered as elementary fire combined, and rendered one of the principles of combustible bodies.

The principal phenomena exhibited by combustible bodies are to kindle, to excite heat and light, to produce the same effects upon other bodies as are produced by the solar rays united in a focus, or by the friction of hard bodies. All these bodies may be inflamed or put into an igneous state by the touch of pure fire rendered active, or, which is the same thing, by the contact of any body actually in the state of ignition.

The combustion of bodies occasions a decomposition and separation of their component principles; and the phenomena of combustion subsist more or less sensibly, till the fire which entered into their composition as a principle be entirely disengaged, exhausted, or dissipated. What remains afterwards of the burnt body belongs to the class of incombustibles. These phenomena leave no doubt that elementary fire enters as a principle into the composition of these bodies. *See* COMBUSTION.

Boerhaave thinks that combustible bodies are not changed into elementary fire during their combustion; because, says he, if it were so, the element of fire would be infinitely encreased: but we may reply, that this event would not happen if this fire, thus disengaged from bodies, be capable of entering into new combinations, and of forming new inflammable bodies; but, from the same reason that it entered into the composition of the first combustible bodies, it may also enter into new similar combinations. Thus, fire continually circulates, like the other elements, which are sometimes pure, free, disengaged from all bodies, and capable of exhibiting all their properties, and sometimes are combined, united with other bodies, and forming compounds in which their properties are more or less disguised and modified by those of the other principles with which they are united; and thus these elements pass alternately in the continued operations of nature from one of these states to the other.

We cannot indeed easily conceive how pure elementary fire, whose parts appear always agitated by a violent motion, and deprived of all cohesion, or of any disposition to adhere in a fixed manner to the parts of other bodies (*see* FIRE) should join, as a principle, in so constant and solid a manner; that is, that each of its primary integrant parts should so strongly unite and adhere to each of the primary integrant parts of any solid body, that it should become deprived of fluidity, mobility, and of almost all the activity which is essential to it. We nevertheless see, from all the chemical phenomena, that the nature and quantity of contact of the integrant and constituent parts of bodies are capable

capable of producing the most surprizing unions and combinations. Facts also demonstrate, that this union of the parts of fire with other bodies really exists; for otherwise we cannot conceive the phenomena of combustible bodies.

The phlogiston, then, or inflammable principle of modern chemists, can be nothing else than the purest and simplest fire, considered in its state of combination, and not in that of aggregation: but we do not yet know whether pure fire be susceptible of combining without any intermediate substance with all the bodies with which we find it united; or whether it cannot enter into these combinations, but by the assistance of an union previously contracted with some substance more disposed than others to combine with it, by means of which it is then rendered capable of entering into all the compounds in which we find it. If this be the case, phlogiston is not pure elementary fire, but this element previously combined with another, and is only a secondary principle. Reasons may be given for and against these opinions, which we shall mention.

First, we shall observe, that chemists have not been able to separate and procure alone what they call the *inflammable principle of bodies*, although they can easily enough procure the other secondary principles. They have only been able to disengage it from bodies by combustion, and then it necessarily resumes the state of pure and active fire, which is well known to be incoercible; or else it is taken from one body by means of another applied to it, with which it unites as soon as it quits the former. In this second case, it is indeed separated from a body without combustion, and without reducing it to actual fire; but it is not obtained alone and pure, since it only quits one combination to enter at the same time into another.

This difficulty, hitherto not surmounted, of obtaining the inflammable principle of bodies in any other state than that of free and active fire, appears to us one of the strongest reasons for believing that phlogiston is nothing else than pure fire, but deprived of its activity by the union it contracts with any substance. If this be the case, phlogiston has no other properties than those of pure fire; or, to speak more accurately, it has no other, as phlogiston, than those which arise from the union of pure fire with the several substances with which it is united. These properties are then peculiar to each of these combinations, and different according to the nature of the substances combined with fire.

However that may be, the power which chemists have of transferring the inflammable principle from one combination to another, with combustion and dissipation, has furnished them with the means of making most important observations on the effects which it produces in many chemical operations, and of remarking the properties which it communicates to the several substances with which it unites. They have compared the properties of a body furnished with its inflammable principle, with those of this same body when deprived of this principle. They have examined the new properties of substances with which they have been able to combine phlogiston. By observing this principle in its progress from one combination to another, and by thus tracing it, Becher, who called it *inflammable earth*, and Stahl, who called it the *principle of inflammability* or *phlogiston*, have been able to give us much light concerning the nature of this substance, which acts so powerfully in almost all the operations of chemistry

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The obſervations of theſe chemiſts, and of ſome others ſince their time, have taught us ſeveral general properties of phlogiſton, which we ſhall firſt relate briefly, without endeavouring to explain them, that they all may be ſeen at once collected, and from one point of view. Beſides, theſe truths will be ſufficiently illuſtrated and proved by the particular relation of the phenomena exhibited by phlogiſton in the ſeveral experiments of chemiſtry, which we ſhall have occaſion to deſcribe.

When phlogiſton is united with an uninflammable ſubſtance, a new compound reſults, which is neither hot nor luminous; but which becomes, by that union, inflammable, and capable of producing heat and light more or leſs eaſily according to the quantity of phlogiſton united with this new compound, and according to the manner in which it is combined.

The principle of fire, by uniting with bodies naturally ſolid, does not render them fluid, but diminiſhes their hardneſs, and renders them more fuſible.

Alſo the compound formed by the union of the inflammable principle with a fixed body is rendered leſs fixed than it was before that union.

It encreaſes the abſolute gravity, and frequently the ſpecific gravity of bodies into which it enters; and in ſome caſes it renders them opake.

Subſtances which have neither ſmell nor color, acquire generally one or the other, and frequently both, by their union with the inflammable principle; and hence chemiſts have been inclined to conſider it as the principle of colors and ſmells. Some bodies indeed, which contain phlogiſton, have neither any ſenſible color or ſmell. But, firſt, we can prove, that theſe bodies contain but a very ſmall quantity of phlogiſton; and, ſecondly, we know no body which contains a large quantity of this principle, which has not more or leſs of color and of ſmell.

Although the compounds in which phlogiſton enters are often very different from each other, yet this principle is not of various kinds, but is always identically the ſame, and ſimilar to itſelf, of whatever nature the bodies may be to which it is united.

Phlogiſton is not equally diſpoſed to unite with all ſubſtances. It combines very difficultly with fluid, volatile, and light matters, ſuch as air and water: perhaps even it never unites with theſe but by means of ſome intermediate ſubſtance; on the contrary, it may be eaſily combined with ſolid, fixed, and heavy ſubſtances, as earths.

Phlogiſton frequently ſerves as an intermediate ſubſtance to unite together bodies incapable of uniting, or very difficultly without it.

We know of no direct combination of phlogiſton with either air or water, that is, we know no body compoſed ſolely of phlogiſton and air, or of phlogiſton and water. But this principle is capable of combining with compounds of which water is a principle: ſuch are oily and ſaline ſubſtances, and particularly vitriolic acid and nitrous acids.

The vitriolic acid cannot unite intimately with phlogiſton unleſs it be dry, that is, unleſs it be deprived of all water ſuperabundant to its ſaline eſſence, extremely concentrated, and contain no water but that which is a principle or conſtituent part of it. From this union an inflammable compound is formed called *ſulphur*. Vitriolic acid in this ſtate quits all bodies to unite with phlogiſton, with which it forms ſulphur; and the ſulphur is always exactly alike,

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from whatever body the phlogiston has been transferred. Thus, whether an oil, resin, fat, coal, or metal, be treated with vitriolic acid, the same sulphur is formed; and since with the same acid all inflammable bodies produce the same compound, therefore the phlogiston of these bodies, however different they may be from each other, is necessarily the same, and consequently this principle is single and identical.

The inflammability of sulphur is caused by the phlogiston it contains; but its flame is not very luminous and ardent; because it contains more vitriolic acid, which is incombustible, than phlogiston.

Sulphur is decomposed by the burning of its phlogiston, which becomes disengaged fire, and dissipates. The vitriolic acid also becomes disengaged, pure, and capable of combining with the phlogiston of another body to form sulphur again, entirely similar to the former.

The vitriolic acid of sulphur is united to phlogiston only, since this acid contains no superabundant water, and also as it is demonstrated that the combustible bodies treated with this acid to form sulphur give it nothing but pure phlogiston. We may therefore discover several of the properties of this principle by comparing sulphur with pure vitriolic acid. The vitriolic acid, which has neither smell nor color when it is pure, forms with phlogiston a compound possessing both these qualities, which are even capable of being rendered much more sensible in some circumstances; as for example, in the combination of liver of sulphur. In the second place, although we cannot certainly know if sulphur be more or less volatile than pure vitriolic acid, because we cannot ever obtain this acid disengaged, without containing at the same time much superabundant water, even when it is in a concrete and glacial form; we have reason, nevertheless, to believe, that sulphur is more volatile than pure vitriolic acid, and that this greater volatility it receives from the phlogiston. This, at least, is evidently indicated by the volatility of sulphureous vitriolic acid, which is infinitely greater than that of simple vitriolic acid.

In the third place, although the disengaged vitriolic acid, particularly when much concentrated, is extremely greedy of moisture, and much more so when deprived of all superabundant water; and although the quantity of this acid be much greater than that of phlogiston in sulphur; yet we see, nevertheless, that sulphur is not soluble in water, which can only be attributed to its phlogiston. This difficulty of uniting with water is common to all the other combinations in which phlogiston is intimately and abundantly combined: for which reason, vitriolic acid cannot form sulphur, unless it be deprived of all superabundant water. This character of dryness, and aversion to unite with water, which the principle of fire preserves in all its combinations, has inclined Beccher to consider it as a principle of a *dry, earthy nature*, and to call it *inflammable earth*, thus signifying an opposition of properties to those of water. We shall not examine now whether Beccher justly made this distinction betwixt what he called a dry and earthy quality, and the humid and aqueous quality; as water is only kept fluid and humid by being penetrated with a certain quantity of disengaged fire, and appears, when deprived of fire, to be as dry and solid as the substances called earthy: but this is certain, that although water perhaps may be essentially as dry as fire, yet these two are of very different natures, and have very little disposition to unite and combine intimately.

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When ſulphur is decompoſed by burning, its acid greedily ſeizes moiſture, as ſoon as it is diſengaged: but as all the phlogiſton does frequently not burn, particularly when the combuſtion is ſlow, a ſmall portion of it remains ſtill united with the aqueous acid. This ſmall quantity of phlogiſton adheres very weakly to the ſulphureous acid, and eaſily ſeparates from it without fire, and merely by expoſure to air: but while it remains united, it communicates properties very different from thoſe which the acid poſſeſſes when pure. The acid is rendered much more volatile; it acquires a pungent, ſuffocating, and inſupportable ſmell; and, laſtly, its ſtrength, or its adheſion to thoſe bodies with which it is capable of uniting, is greatly diminiſhed. It is then called *volatile ſulphureous acid.*

We may obſerve, that although vitriolic acid has a great affinity with phlogiſton, the preſence of water prevents the intimate union of theſe two ſubſtances. Hence, when vitriolic acid is combined with inflammable matters, if any water be contained either in the acid or in the inflammable matter, no ſulphur, but a volatile ſulphureous acid will be formed. Sometimes indeed true ſulphur is formed even in liquors, and by the humid way; but by ſome means the vitriolic acid and the inflammable principle muſt be ſeparated from all ſuperabundant water, elſe the intimate union by which ſulphur is formed, will not happen. *See* ACID (VITRIOLIC), ACID (VOLATILE SULPHUREOUS), SULPHUR, *and* LIVER *of* SULPHUR.

Phlogiſton has alſo a ſtrong affinity with nitrous acid, even ſtronger than with the vitriolic, as we ſhall ſee from the following facts. For, firſt, the volatility of the nitrous acid, its color, its ſmell, its inferiority of ſtrength compared with vitriolic acid; laſtly, its inflammability, and its total decompoſition by inflammation, prove, that phlogiſton enters into the compoſition of this acid, and is one of its conſtituent parts. Stahl and moſt chemiſts think, and with much probability, that nitrous acid differs only from the vitriolic by its containing phlogiſton.

In the ſecond place, nitrous acid acts more ſtrongly in general than vitriolic acid upon all compounds which contain the inflammable principle, and deprives them more effectually of this principle, as is peculiarly obſervable in ſolutions of metals, Beſides, nitrous acid ſeems to act nearly as vitriolic acid does with regard to its combinations with a quantity of phlogiſton ſuperabundant to its compoſition; but ſome differences may be perceived, which ought to be attributed to the inflammable principle which makes part of its combination. Like the vitriolic acid, it cannot unite with phlogiſton in the moſt intimate manner, unleſs it be in a dry ſtate: it then forms a kind of ſulphur which may be called *nitrous ſulphur*, which, from the phlogiſton already contained in the acid, is ſo inflammable, that it kindles as ſoon as it is formed, and therefore has never been obtained alone and uninflamed, as we obtain the vitriolic ſulphur. *See upon this ſubject* DETONATION *of* NITRE.

When the nitrous acid contains ſuperabundant water, it ſtill acts very powerfully upon the phlogiſton of moſt bodies; but no inflammation happens, excepting that during the act of combination, the phlogiſton and acid can be rendered dry; without which circumſtance, only a ſuperficial and weak union of theſe two ſubſtances can be made. The aqueous nitrous acid does indeed attract phlogiſton ſuperabundantly, by which its color, ſmell, and volatility, are

considerably encreased; of which we see very evident examples in the solutions of almost all metallic matters by this acid, as of iron, zinc, copper, tin, &c. But then this phlogiston adheres but weakly to the acid, because of the water of the acid, as it does, for the same reason, to the volatile sulphureous acid; and it separates, without heat, by mere exposure to air.

Although nitrous acid be probably capable of thus attracting superabundantly a larger quantity of phlogiston than vitriolic acid, we do not observe, nevertheless, that this superabundant phlogiston produces such a change upon the nitrous acid, as it does upon the pure vitriolic, when it converts this latter into the volatile sulphureous acid. The cause of this evidently is, that nitrous acid in its natural state contains already so considerable a quantity of phlogiston as one of its principles, that it has in a certain degree all the properties of a phlogisticated acid; and these qualities ought not to be changed, but only rendered more sensible by the addition of a superabundant quantity of phlogiston: whereas the vitriolic acid in its pure state, not containing any phlogiston, or at least not sensibly, must, by such an addition, pass from the state of an unphlogisticated acid to that of an acid united with the inflammable principle, when from a pure vitriolic acid it becomes a volatile sulphureous acid, by which it is rendered entirely different. This seems to me to be one of the best proofs that nitrous acid contains phlogiston as a principle and constituent part. *See* Acid (Nitrous).

As the acid of common salt has smell, color, and particularly much volatility, it seems provided with all the properties of an acid united with the inflammable principle. Nevertheless, we do not see that it has the same disposition as the vitriolic and nitrous acids to combine itself with this principle, neither intimately, nor even superficially. On the contrary, it is incapable of acting upon many inflammable matters, for instance, oils; it acts more weakly upon metals, deprives them of less of their inflammable principle, and adheres to them more strongly than the other two mineral acids. Lastly, we do not know any immediate combination of marine acid with phlogiston, that is, any *marine sulphur*; for the phosphorus of Kunckel, which has been believed to be such by Stahl and other chemists, is not a marine sulphur, as we shall see in its place. From what cause then do properties so contradictory proceed? We know too little of the true nature of the marine acid, and of the principle which distinguishes it from the other acids, to be capable of saying any thing satisfactory upon this subject. According to Becher, the mercurial earth distinguishes this acid from the others. If this be true, the union of phlogiston with marine acid is prevented by this earth. But, on the other side, this earth appears to have many of the properties of phlogiston, both from the properties of marine acid, and from those of metals, which also are supposed to contain mercurial earth: or, is not this union of phlogiston with marine acid prevented by a certain modification of the phlogiston itself contained in that acid, by which its nature is in some measure changed, as Henckel seems inclined to think? Let us hope for further illustration of this obscure matter from time, experience, and the advancement of chemistry. *See* Acid (Marine).

Fixed alkalis shew in many experiments a considerable disposition to unite with phlogiston. Their properties shew even that this principle is one of their constituent parts; nevertheless, they seem to have less affinity with phlo-

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giſton than the vitriolic and nitrous acids, or even than metallic earths. The phenomena exhibited by them when united with inflammable matter have not been ſufficiently examined. In ſome caſes, they acquire a very pungent and pungent ſmell, and extreme volatility, as when they are changed into volatile alkali; which happens, as is known, by combining and diſtilling them with fat matters. In other caſes, they may be ſaturated with an inflammable matter, with which they appear to be intimately united, although they do not acquire the ſmell and volatility of *volatile alkali*. This happens when they are calcined in cloſe veſſels with coals, as in the preparation of the ſaponaceous alkali for the Pruſſian blue. Are theſe two combinations of alkali with phlogiſton any thing ſimilar to the combinations of the vitriolic and nitrous acids with the ſame principle? I am inclined to believe ſo; but this matter requires further examination. *See* ALKALI (FIXED).

Phlogiſton then appears to have a ſtrong diſpoſition to unite with dry and earthy matters, and to adhere to them ſtrongly: but notwithſtanding this diſpoſition, we cannot make this combination with any given proportions of theſe matters, nor with any of the ſubſtances containing phlogiſton. I do not know that phlogiſton would quit the vitriolic acid or metals to unite with a ſimple earth: we have no reaſon to preſume that this could be effected, unleſs perhaps by very nice and difficult proceſſes. This is certain, that although theſe reſearches be very intereſting, as they are connected with the theory of the compoſition of metals which ſeem to be formed of earth and phlogiſton, they have not been ever made; or, at leaſt, the attempts of chemiſts upon this ſubject have not been diſtinctly publiſhed. *See* METALS *and* METALLIZATION.

Several kinds of earths, particularly thoſe the parts of which are naturally very fine and much divided, ſuch as calcareous, and more eſpecially argillaceous earths, appear the fitteſt to be united with the inflammable principle; and further, phlogiſton ſeems to be moſt diſpoſed to unite with theſe earths when it is in the ſtate of oil, of ſoot, or of vapors. Accordingly, when calcareous or argillaceous earths have been mixed with fat matters, and have afterwards been expoſed to the action of fire in cloſe veſſels, they retain much of the phlogiſton of theſe matters, which adheres ſtrongly, and communicates color to them, particularly ſhades of blackneſs, which cannot afterwards be ſeparated but by a very long calcination in an open fire. In Mr. Macquer's Memoir upon Clays, we may ſee, that when theſe earths are expoſed to violent fire, although many of them be naturally white, and others become white by a moderate heat, they all acquire colors when expoſed to violent fire, apparently from contact of phlogiſtic vapors; and that theſe colors, which are black, grey, yellow, greeniſh or bluiſh, remain obſtinately without any poſſibility of deſtroying them. *See* CLAYS.

The coals of vegetable and animal matters are nothing elſe than ſingular combinations of the earthy part of theſe organiſed bodies with the inflammable principle of their oils and fat. All the properties of coals ſhew us, that although their phlogiſton be in a very combuſtible ſtate, it nevertheleſs adheres to them in a very fixed manner, ſince they can ſupport the moſt violent fire in cloſe veſſels without the leaſt alteration, or loſs of any part of their inflammable principle.

This principle, however, is not so adherent to the earth of coals, that it cannot quit it to combine with other substances, with which it has a stronger affinity; for instance, with the vitriolic, nitrous and phosphoric acids, and with metallic earths. Accordingly, coals by exposure to a violent fire in close vessels together with any of these substances, are decomposed, their phlogiston is separated and combined with the substance applied to it, with which it forms a new inflammable compound; common sulphur, for instance, with vitriolic acid; nitrous sulphur with nitrous acid; phosphorus with phosphoric acid; and, lastly, metals, with metallic earths: coal is therefore one of the fittest inflammable substances for transmitting phlogiston to other matters, and therefore is much employed for that purpose in chemical operations. *See* Coal.

The properties of phlogiston are particularly evident and distinct in metallic matters. The decomposition and recomposition of all imperfect metals and semimetals, by the substraction and restitution of the inflammable principle, leaves no doubt that this principle is one of their essential constituent parts. This is a chemical truth, which may be considered as demonstrated.

We may separate phlogiston from metallic matters by the general method by which it may be separated from all combustible bodies, that is, by combustion in open air; for without this condition, the phlogiston of metals, even the most combustible, is no more capable of burning in close vessels than that of coals. *See* Calcination, Calx (Metallic), *and* Combustion.

All mineral acids, and even the combined action of water and of air, are capable of depriving metals of their phlogiston, which is then done without any combustion.

Metals calcined, reduced to calxes or earths by some of these methods, or rather metallic earths, are capable of combining again with phlogiston, and of resuming all the metallic properties by several methods; that is, by fusion with coal, or other inflammable matters which are converted into coal during the operation. This is the ordinary method of reducing or recomposing metals. *See* Reduction. Metallic earths may also recover their phlogiston, by applying this principle in the state of vapors, or even by the humid way, by treating them with liver of sulphur, oils, &c. But the phlogiston of metals seems to be nevertheless in a dry state, as well as the phlogiston of sulphurs and of coals, as all the properties of metals shew. Thus if their earths are capable of recombining with the inflammable principle, even by the humid way in certain circumstances, the humid combination of phlogiston must be itself decomposed on these occasions, and this principle must be separated from all moisture to combine, at least in an intimate manner, with metallic calxes, and to reduce them into true metals. This reduction is similar to the production of sulphur in the humid way. *See* Reduction *and* Sulphur.

As the calcination and reduction of metals are performed by the separation and restitution of the inflammable principle alone, we may, by comparing the properties of metals with those of their calxes, obtain demonstrative proofs of many of the essential properties of phlogiston, which we have mentioned in the beginning of this article.

Metallic calxes are generally harder, more solid, more fixed, less dense, less fusible, less opake than the metals. All these qualities then, more or less eminent in metals, proceed from phlogiston. Further, the earths of metals,

by losing their phlogiston, lose also their solubility in acids: hence phlogiston is an intermediate substance by which metals are dissolved in acids, from the great affinity which it has with these solvents. We shall now mention some particular instances of what we have here advanced in general.

Lead and tin are very soft metals; nevertheless, when lead is calcined and afterwards melted, a glass is formed much harder than the lead from which it was produced. Tin, which calcines still more compleatly than lead, is easily changeable into a white earth, the parts of which, though very fine, are so hard, that they are employed to polish very hard bodies, as steel, glass, &c.

The most volatile semimetals, as regulus of antimony and zinc, are changed by burning their phlogiston into perfectly fixed earths.

Regulus of antimony and tin are fusible with a gentle heat; yet the calxes of these metals are justly considered amongst the most refractory bodies.

The density, opacity, and ductility which metals receive from their phlogiston evidently proceed from the particular manner in which the parts of the phlogiston are applied to those of the metallic earths. These properties seem to shew that the primary integrant parts of phlogiston, although perhaps the smallest of all imaginable atoms, are essentially very dense and very opake; and also, that to give these qualities so eminently to metals, they must be capable of filling very accurately the small interstices betwixt the primary integrant parts of the metallic earths. The last mentioned properties of phlogiston seem to favour the opinion of Beccher and Stahl, who consider it as an earthy substance, the parts of which are exceedingly small, not, or but little, coherent to each other, and fitter than any other substance to acquire the rapid motion in which consist all the effects of fire; or rather, it is the only substance capable of receiving the igneous motion. *See* METALS *and* METALLISATION.

Although phlogiston shews, in all chemical experiments, a strong repugnancy against uniting with water, and even with any substances containing water, we, nevertheless, find it combined with this principle in oils, resins, and in all vegetable and animal inflammable substances. We cannot doubt that these matters contain water; for it is obtained in their analysis, and also their inflammability sufficiently proves that phlogiston is one of their constituent parts. Hence we find, that these two substances may assist in the composition of one body: but probably they are not united together immediately in oily compounds, but by means of an earth or rather of an acid; for we know that phlogiston unites much more readily with earths and acids than with water; and also, that earths and acids are obtained in the analysis of all oily substances.

As then oils are much more compounded than sulphurs, metals, and coals, the phenomena exhibited by phlogiston in oily matters are different from those in these other inflammable bodies. Phlogiston adheres less to oily matters, and is more readily combustible, and also when it is disengaged by inflammation it is always accompanied with some of the other principles of the oily matter which it carries along with it, that is, of the water, acid, and earth which compose this matter; all which together form an oily flame. In this combustion even all the phlogiston is not dissipated: one part of it attaches itself much more intimately with the earth of the oil, and forms with this earth a matter black,

very fixed, and much less combustible than oil, called *lamp-black* or *soot*. It is a kind of coal, and is considered by Stahl as almost pure phlogiston.

This fuliginous quality by which oils differ from other inflammable matters, is in a greater or less degree, according to the nature of oils, and the greater or less activity with which they burn; in general, the more quickly and strongly they burn, the less fuliginous matter is formed; so that perhaps if an oil was reduced altogether to vapors, it might be burnt in an instant without forming any fuliginous matter.

When oils are decomposed without combustion, and by distillation, something similar happens. The phlogiston of the decomposed part of the oil attaches itself to the fixed and earthy part of the oil, intimately unites with it, and forms a coal. In this manner are all coals made.

Oil can transmit phlogiston to all the substances capable of uniting with it: but in the formation of intimate combinations, as those of sulphur and metals, the water must necessarily be separated from the oil. The same also is observable of soot and coal, although these substances have been produced from oil itself; yet their phlogiston is never in a state of perfect combination, unless they be quite dry. *See* OILS *and* COAL.

Ardent spirit and the *spiritus rector* of vegetable and animal substances are also compounds in which are contained both phlogiston and water; for these substances are, at the same time, very inflammable and miscible with water. Besides, water is obtained in their decomposition. The phlogiston of these substances is, nevertheless, in a very different state from that of oils; for their flame is less luminous, and is not accompanied with any soot. The cause of this difference probably is, that phlogiston is more immediately united with water in these spirits than in oils. Some chemists even imagine, that in ardent spirits phlogiston is united to water without any intermediate substance. The acid is certainly in less quantity and less sensible in spirituous inflammable liquors than in oils properly so called; and also these spirits may be approximated to the nature of oils, or even changed into true oils, by treating them with acids. *See* OILS SPIRIT (ARDENT), SPIRITUS RECTOR, *and* ETHER.

From these properties of phlogiston it appears, that it is a principle dry, volatile, susceptible of the igneous motion, capable of combining with primary principles, as earth and water, but much more difficultly with this latter; that it is a component part of many bodies, to which it communicates an inflammable quality; that it is capable of passing from one combination to another; and that it is identical, or the same in all compounds, as the other principles are. Stahl thinks, that phlogiston is not elastic; and indeed most inflammable vapors, in which this principle seems to be almost pure, are not elastic: on the contrary, they destroy the elasticity of the air.

Hitherto the inflammable principle has never been obtained pure and single; and if it be nothing else than the matter of elementary fire, we evidently can never obtain it otherwise than as we have done; that is, in active and burning fire, by collecting the solar rays, &c. Nevertheless, in many occasions phlogiston discovers itself without inflammation, if not absolutely pure and simple, at least considerably so. Stahl believes, as we have already said, that soot is almost pure phlogiston. This matter does indeed seem to be one of the simplest combustible matters: but its great fixity and small degree of combustibility

bustibility prove that in this substance the phlogiston is intimately united with a considerable quantity of very fixed earthy matter, which is capable of disguising many of its essential properties. I believe therefore, that we may consider the very volatile, not inflamed vapors rising from several combustible bodies on certain occasions, as phlogiston still more simple, more copious, and more disengaged. Such, for instance, are the vapors of sulphur formed into liver of sulphur, particularly when it is precipitated by an acid, or exposed when dry to a gentle heat, incapable of kindling sulphur: such also are the vapors of coals of all kinds when they burn weakly and slowly, because then a considerable quantity of the inflammable principle of these coals is exhaled without being inflamed. The subtile vapors disengaged from matters undergoing the spirituous and putrid fermentations, the vapors of mines and subterranean places, called *damps*, appear also to be of the same kind. All these vapors are similar in this respect, that when they are not at liberty to dissipate themselves in open air, they have the property of absorbing air, or of destroying its elasticity, and of acting suddenly upon the brain and nervous system of men and animals, whom they affect with drunkenness, stupefaction, suffocation, syncope, and death. These exhalations are all susceptible of being instantly inflamed, and with more or less explosion, according to circumstances, when they are accumulated and confined in a place, and a lighted substance applied to them. These vapors then are considerably analogous. They all proceed from bodies abounding in inflammable principles, and are themselves inflammable: lastly, when they are applied to any body capable of combining easily with phlogiston, such as, for instance, metallic calxes not much dephlogisticated, they very quickly and easily adhere to it. We seem then to have reason to presume, after all these facts, that these emanations are nothing but the inflammable principle, almost pure, and which is but weakly connected with some other principle.

Such are the chief properties of this principle, the knowledge of which has become so important and essential since the discoveries of Beecher, Stahl, Geoffroy, and other modern chemists.

DXXXVII. PHOSPHORUS (ENGLISH), or KUNCKEL'S PHOSPHORUS. The name *phosphorus* is applied to all substances capable of giving light in the dark; such as glow-worms, rotten-wood, diamonds after having been exposed to the sun or light, the Bolognian stone, and certain spars after calcination. The effects of these phosphoric matters proceed from electricity, or some property of light. We shall mention these in the following article. The phosphorus we now treat of is of a very different nature. It is a substance not only luminous in the dark, but also inflammable and burning. It is a combination of phlogiston with a peculiar acid, and is consequently a species of sulphur.

The discovery of this phosphorus is not very ancient: it was discovered by a citizen of Hambourg, called Brandt, in his researches for the philosopher's stone. Kunckel was desirous to acquire this secret, and for this purpose associated himself with one of his friends, called *Kraaft*, who thinking by means of it to make a fortune, resolved, after having procured it, not to reveal it, and even obtained a promise from the inventor not to communicate it to Kunckel.

Kunckel,

Kunckel, vexed by this treachery, resolved to search for the phosphorus: and although he knew no more of the process than that urine was the substance employed, he prosecuted this inquiry with such zeal, that at length he made phosphorus. This chemist took to himself very justly the honor of having discovered it, and was accordingly considered as one of the discoverers of it, with so much more reason, as he did not find it by chance, and without searching for it, as Brandt had done, but after a rational inquiry undertaken for this purpose. Accordingly Kunckel's name is affixed to this phosphorus, which is commonly called the *phosphorus of Kunckel.*

The celebrated Mr. Boyle has also had the reputation of having made this discovery. Those who give him the credit of this, say, that Boyle having seen a bit of phosphorus in England in 1679, which Kraaft had brought thither to shew to the King and Queen of England, and having been informed only that this phosphorus was produced from some matter belonging to the human body, attempted, like Kunckel, to discover the method of preparing it, and in the following year actually made a small quantity, which he lodged with the secretary of the Royal Society, who gave him a receipt for it. But Stahl, in a small work called the *three hundred experiments*, says that Kraaft told him that he communicated the process to Mr. Boyle. If this be true, Boyle has claimed the honor of a discovery to which he had no right, an imputation injurious to the reputation of a man so justly famous. But we must acknowledge, that the truth of this imputation is very questionable. For Kraaft, who, as Stahl relates, was ignorant of chemistry, who had been treacherous to Kunckel, was nothing in all this affair of phosphorus, but a trader in secrets. For having purchased the secret of preparing phosphorus, he sold it again every where, and therefore no credit is to be given to the testimony of such a man. However that may be, Boyle communicated the process for making phosphorus to a German chemist called Godfreid Hantkwitz, who accordingly prepared it in London. Kunckel and he were then the only persons who made any considerable quantity of it, and the latter made a lucrative trade of it. Stahl says, that he knew also this Mr. Hantkwitz, and considered him as a good practical chemist, and that he had an excellent laboratory in London.

Processes for making phosphorus were frequently published about that time. Mr. Hellot, in his Memoir upon this subject, enumerates all that were then known, namely, the process published by Boyle in 1680, in the Philosophical Transactions, No. 196; that of Kraaft; for, after selling the secret to many persons, he afterwards published it, in a treatise concerning phosphorus written by the Abbé de Commieres, published in the Mercure Galant for June 1683; that of Brandt, in a Collection of Experiments and Observations of Dr. Hook, published by Mr. Derham in 1726; that of Mr. Homberg, in the Ancient Memoirs of the Academy in 1692, who says that he had seen Kunckel make phosphorus; and, lastly, the processes found in the works of several chemists, particularly of Theickmeyer, Hoffman, and Neewentuit.

But notwithstanding all these processes, whether they were not sufficiently compleat, or too laborious and expensive, no chemist, excepting Hantkwitz, made phosphorus, and the operation still continued a secret till the year 1737, when a stranger came into France, who offered to make phosphorus. The ministry granted him a reward for his process, which he accordingly communicated.

municated. Messrs. Hellot, Dufay, Geoffroy, and Duhamel, all experimental philosophers and chemists of the Academy of Sciences, executed this process successfully. Mr. Hellot wrote a distinct account of it, and published it amongst the Memoirs of the Academy of Sciences for the year 1737; a large extract of which may be found in the Elements of Practical Chemistry.

Since the publication of the memoir of Mr. Hellot, the process of phosphorus has been no longer a secret. But as this operation has hitherto been rather curious than useful, and is also expensive and troublesome, I do not know that any French chemist repeated it at that time, excepting Mr. Rouelle, who soon afterwards began a course of chemistry, in which he undertook to make phosphorus in presence of his pupils. I was then present as one of these, and Mr. Hellot attended during the whole operation. We continued there the whole night; but from a fault in the retort, this first operation failed. However, in the years following Mr. Rouelle succeeded many times.

Lastly, in 1743, that intelligent chemist Mr. Margraaf, who had several years been employed in making experiments upon phosphorus, published in the Memoirs of the Academy at Berlin a new and excellent process for obtaining more easily and expeditiously, and at less expence than has been done hitherto, a considerable quantity of phosphorus. This process is repeated successfully every year by Mr. Beaumé in the courses of chemistry which he gives with Mr. Macquer.

To make phosphorus by Mr. Margraaf's process, a kind of plumbum corneum is previously prepared, by distilling a mixture of four pounds of minium with two pounds of powdered sal ammoniac, from which all the volatile alkali, which is very penetrating, is by this operation obtained. The residuum after the distillation, that is, the plumbum corneum, is to be mixed with nine or ten pounds of extract of urine boiled to the consistence of honey. Mr. Margraaf requires that this urine should be putrified, which is unnecessary, according to Mr. Beaumé's observation. This mixture is to be made slowly in an iron caldron set upon the fire, and by frequently stirring the matters. Half a pound of powdered charcoal is then to be added, and evaporation is to be continued till the whole is reduced into a black powder. This powder is to be put into a retort, to extract from it, by a moderate and graduated heat, all the volatile products of urine, that is, volatile alkali, fetid oil, and an ammoniacal matter which adheres to the neck of the retort. In this distillation the heat is to be only raised so as to make the matter red-hot. After the distillation a black and friable residuum remains, from which the phosphorus is to be extracted by a second distillation, and a stronger heat. Before it is exposed to another distillation, it may be tried by throwing some of it upon hot coals. If the matter has been well prepared, a smell of garlic exhales from it, and a blue phosphorical flame is seen, undulating along the surface of the hot coals.

This matter is to be put into a good earthen retort capable of sustaining a violent fire. Mr. Margraaf recommends retorts of *Waldenbourgh*, or those which are made near *Kirchan* in Saxony; which not being known in France, we use Hessian retorts, although they have the inconvenience of allowing a large quantity of phosphorus to transpire during the operation. Mr. Beaumé secures his retorts with a covering of clay and hair.

Three quarters of the retort are to be filled with the matter which is to yield the phosphorus. It is to be placed in the common furnace for distillation with a retort; excepting that instead of being terminated by an ordinary reverberatory or dome, this ought to be terminated by the upper piece of an air-furnace, to which a tube is to be applied, the diameter of which ought to be from four to six inches, according to the size of the furnace, and the height from eight to nine feet. This apparatus, which Mr. Beaumé uses, is necessary for raising a sufficient heat, and for the conveniency of throwing in a sufficient quantity of fuel through the door of the upper piece of the furnace. The retort ought to be well luted to a receiver of moderate size, pierced with a small hole, and half full of water. For this purpose ordinary fat lute may be bound on with strips of linen, dipped in a lute prepared with lime and whites of eggs. The hole in the furnace through which the neck of the retort passes ought to be well stopped with furnace earth. Lastly, a small wall of bricks is raised betwixt the furnace and receiver, to guard this vessel against heat as much as is possible.

All these preparations being made the evening before the distillation is to be performed, we are then capable of proceeding to this operation, which is very easy. The retort is to be heated by slow degrees during an hour and a half; and then the heat is to be encreased till the retort be red-hot, and the phosphorus begin to pass in luminous vapors: when the retort is almost of a white red heat, the phosphorus passes in drops, which fall and congeal in the water at the bottom of the receiver. This degree of heat is continued till no more passes into the receiver. When a retort contains eight pints or more, this operation continues about five hours.

Mr. Margraaf's apparatus is somewhat different from that above described. He divides the whole quantity of matter from which the phosphorus is to be obtained into six small retorts, which he places in a furnace that he describes. The advantage of this division is, that it any accident happens to one retort, the whole matter is not lost; and as the retorts are smaller, a less heat is required. If indeed much phosphorus was to be made, this practice would be safe and excellent; but I can affirm, that the method above described of Mr. Beaumé is very convenient when a large quantity of phosphorus is not wanted, and that I have never seen it fail.

Phosphorus does not pass pure in this distillation, but is blackened by soot or coal, which it carries along with it: It may be easily purified and rendered white and fine by a second distillation or rectification. This rectification is made in a small glass retort, to which is adjusted a small receiver half full of water. A very gentle heat is sufficient, because phosphorus once formed is very volatile: and as the fuliginous matters with which it is soiled were raised merely by the violence of the heat, they remain at the bottom of the retort in this distillation; and the phosphorus passes very pure.

The phosphorus is then usually divided into small cylindrical rolls, for the conveniency of using it. This is done by putting it in glass tubes immersed in warm water. This very gentle heat is sufficient to liquefy the phosphorus, which is almost as fusible as suet. It takes the form of the glass tubes, from which it may be taken out when it is cold and hardened. That it may be more easily taken out of the tubes, these must be somewhat of the form of frustums of

of cones. All these operations ought to be made under water, to prevent the inflammation of the phosphorus.

The process published by Mr. Hellot for the preparation of phosphorus is only different from this in two respects; first, that his is only o e operation, and not divided into two, as Mr. Margraaf's is; and, secondly, that he does not use plumbum corneum. The operation is certainly much facilitated by Mr. Margraaf's method of separating the volatile matters of the urine by a previous distillation; because after that, nothing more is requisite but to apply heat sufficient to raise the phosphorus; which may be done in four or five hours; whereas without this previous operation, the distillation lasts twenty-four hours. We are not so certain concerning the advantage of adding plumbum corneum, or whether it might not be omitted; for, as this addition does not much encrease the trouble of the operation, chemists who have hitherto made phosphorus by Mr. Margraaf's process have followed it in every point, without making any experiments to determine the necessity of this addition.

Phosphorus is a kind of sulphur composed of a peculiar acid united with phlogiston. This matter is extremely fusible, as we have seen. It has, like sulphur, two kinds of inflammation; one very weak, emitting a flame not powerful enough to kindle other combustible matters, but sufficient for the gradual consumption and burning of its own phlogiston; the other is vivid, brilliant, and strong, accompanied with decrepitation, and capable of kindling instantly any combustible matter. These two flames of phosphorus are easily distinguishable during the distillation of it, when the small hole of the receiver is unstopped; for when the vessels are not too much heated, the flame which issues through the hole is luminous in the dark, but does not kindle any combustible matter; it may be touched without danger, and it only renders the hands that touch it luminous. But when the vessels are too much heated, the flame issues with more force; it then decrepitates, and is capable of burning any person that touches it. This flame is a sign that the heat is too strong, and therefore when it is perceived, the fire ought to be lessened.

Phosphorus resembles vitriolic sulphur also in this point, that all its phlogiston may be burnt, even with rapidity, without any decomposition of its acid.

But it differs from sulphur in being much more combustible. In this circumstance it seems to be in a middle state betwixt the vitriolic and nitrous sulphurs. A heat from twelve to fifteen degrees is sufficient to decompose phosphorus, and to make its phlogiston burn, weakly and slowly indeed, but with a sensible light, particularly in open air. To prevent this decomposition, it must be preserved under water; and even in water it is partly decomposed, and it fills the containing bottle with luminous vapors; its surface loses its semi-transparency, and becomes farinaceous; and the water becomes more and more acid.

When phosphorus is heated by fire, or by friction, it then violently inflames, burns fiercely, and emits many vapors, as sulphur does; which however differ from those of sulphur in smell, which is like that of garlic or arsenic; and also in being always visible, as a white smoke during day, and as a light, when in the dark.

Phosphorus does not seem to be so strongly disposed as sulphur is to unite with metals. Mr. Margraaf has tried to make this combination with all metals

and ſemi-metals. For which purpoſe he took ſome filings of each metallic ſubſtance, digeſted it with two parts of phoſphorus, and diſtilled the mixtures. In all theſe experiments part of the phoſphorus paſſed into the receiver, as when it is rectified; the other part was burnt, and the metals remained untouched, excepting copper and zinc, which were acted upon in the following manners.

Copper treated by Mr. Margraaf with phoſphorus loſt its metallic brilliancy, and became more compact; a gros or 72 grains of copper being twice treated in this manner with phoſphorus, was found to have acquired ten grains in weight, and to be rendered capable of being kindled when expoſed to flame.

Zinc treated twice with phoſphorus in the ſame manner, and expoſed to ſtrong heat at the end of the ſecond diſtillation, was ſublimed almoſt entirely in form of light pointed flowers of a reddiſh-yellow color, which being put under a muffle, were inflamed and vitrified, forming a tranſparent glaſs like that of borax. From theſe experiments we ſee that phoſphorus has little diſpoſition to unite with metals, which property perhaps proceeds from the facility with which it is decompoſed.

According to the experiments of the ſame Mr. Margraaf, phoſphorus ſublimes with arſenic into a compound of a ſhining red color, in which reſpect it reſembles common ſulphur. It eaſily unites with ſulphur. Equal parts of theſe two matters being mixed together and diſtilled, paſſed into the water of the receiver, congealed there, forming a ſubſtance which when rubbed by the fingers, could not eaſily be inflamed, but gave a yellow light, and readily kindled when expoſed to a heat nearly equal to that of boiling water. Mr. Margraaf ſays, that this compound had a fœtid ſmell, like that of liver of ſulphur; and that it ſwelled in water, to which it gave a ſulphureous ſmell, and manifeſt acidity; which effects prove a decompoſition of theſe ſubſtances.

Mr. Margraaf treated phoſphorus alſo with the three mineral acids by diſtilling them together in a retort; and theſe experiments furniſhed very curious obſervations. Vitriolic acid decompoſed almoſt entirely phoſphorus, but without any inflammation. Nitrous acid attacked it with violence, even without the help of fire, and occaſioned a ſudden inflammation, with exploſion and rupture of the veſſels. Laſtly, marine acid produced no alteration upon phoſphorus, nor was itſelf altered. Theſe phenomena are perfectly analogous to the affinities of the three mineral acids with the inflammable principle.

Phoſphorus is ſoluble in oils and inflammable liquors, nearly as ſulphur is, and conſequently forms *balſams of phoſphorus*. But when combined with theſe ſubſtances, it ſeems to be more diſpoſed to decompoſe, than when it is alone; for theſe oily phoſphoric liquors are always luminous, particularly when they are heated a little, and are expoſed to air.

But phoſphorus differs eſſentially from ſulphur by the nature of its acid, which is not yet well known by chemiſts. They believed a long time that it was the ſame as marine acid. Stahl was of this opinion, and others received it. That great chemiſt, in other reſpects ſo accurate and ſo much to be credited, was induced to this opinion by conſidering that urine contains much common ſalt, and that common ſalt expoſed to contact of burning fuel is reduced to flowers, makes the coals burn more intenſely, and occaſions a flame ſimilar to that of phoſphorus. We have reaſon to wonder that ſuch a chemiſt

as Stahl should pronounce concerning the nature of this acid from so slight reasons, when we consider that the properties of the phosphoric are so very different from those of the marine acid. But we shall be more surprised to find that he positively affirms, in his book called *Three Hundred Experiments*, that to make phosphorus, nothing more is requisite, but to mix and combine properly marine acid with phlogiston; and that by prosecuting what he had published concerning the artificial composition of sulphur, we may make phosphorus as abundantly and easily as sulphur itself.

We cannot wonder that chemists, trusting to so great an authority, shou'd have firmly believed that the acid of phosphorus was the same as marine acid. Accordingly when Mr. Margraaf undertook to simplify and improve the process for phosphorus, he made many experiments to combine marine acid directly with phlogiston. We see in his memoirs, that he made these trials not only by employing common salt, but also several combinations of its acid with other bases. He employed *sal ammoniac*, *corneous metals*, and *marine salt* with earthy bases. He also varied the matters which were to furnish the inflammable principle; instead of urine he employed several vegetable coals, and even other animal matters, such as the oil of hartshorn, human blood, &c. But all these experiments were unsuccessful, or yielded but a very small quantity of phosphorus. He found the necessity of returning to the use of the extract of urine: and Mr. Margraaf having tried to distil it alone, and being assured by comparative experiments that this extract produced as much phosphorus when he distilled it alone as when he mixed it with matters capable of furnishing marine acid, as, for instance, luna cornea, this able chemist then suspected that the phosphoric acid was different from that of common salt.

On the other side, as urine contains, besides common salt, a considerable quantity of a singular kind of salt, which chemists call *fusible salt*, or *native salt of urine* (See URINE), Mr. Margraaf, who found that he could not obtain phosphorus from common salt, nor from any of the combinations of its acid with other bases, was naturally led to suspect that this native salt of urine contained the true phosphoric acid. This he afterwards ascertained by many demonstrative experiments. Having distilled this salt only with inflammable matters, he easily obtained a very large quantity of phosphorus; and also having distilled an extract of urine, from which he had separated all the fusible salt, and having by this method obtained scarcely any phosphorus; and, lastly, having examined and compared the properties of the phosphoric acid with those of the acid of the fusible salt, and having found them entirely the same, he acquired on this subject all the certainty which is possible. We shall see from the enumeration of the properties of phosphoric acid, how much it differs from the marine, and all other acids. To Mr. Margraaf also we owe the knowledge we have concerning this important subject.

When the inflammable principle of phosphorus burns, and separates from the acid by this combustion, the acid remains disengaged, as the acid of sulphur does, by the combustion of sulphur. We obtain then, after the combustion of phosphorus a substance at first dry, but which quickly and powerfully attracts the moisture of air, because the acid is so concentrated as to be dry. This matter is soon reduced to a very acid liquor, of the consistence of very concentrated vitriolic acid. It has an acid taste, it converts the blue color of vegetables to a red, and combines to the point of saturation with

alkaline

alkaline ſubſtances. Thus its acid quality is not doubtful. The fixity of this ſalt is very ſingular It not only may be deprived by heat of all the moiſture by which it is kept liquid, but alſo when thus dried it may be rendered red-hot without ſublimation, and may be thereby changed into a ſolid and tranſparent matter, which has all the appearance of glaſs. Mr. Margraaf obſerved that phoſphoric acid, thus dried and heated, emitted a ſmell of garlic, and alſo ſome luminous ſparks; which proves that phoſphorus does not loſe by combuſtion all its phlogiſton, but that a portion of it ſtill remains united with the acid, and which ſeems to have been protected from combuſtion by this acid.

Phoſphoric acid appears to be a very powerful ſolvent. It eaſily decompoſes nitre and common ſalt, from which it diſengages the acids and unites with the alkaline baſes, as vitriolic acid does. According to Mr. Margraaf's experiment, it alſo decompoſed vitriolated tartar. Theſe remarkable properties ought probably to be attributed to its great fixity.

When it is combined to the point of ſaturation with alkaline ſalts, it forms neutral ſalts entirely ſimilar to the fuſible ſalt of urine.

Mr. Margraaf has alſo examined the action of the phoſphoric acid upon metals. From theſe experiments we find that this acid does not diſſolve gold, not even when mixed with the nitrous acid; which proves that it is very different from marine acid. It does not attack ſilver. It acted a little upon filings of copper, which rendered it green, but it eaſily diſſolved the calx of copper. Iron is entirely and eaſily ſoluble in this acid, and forms with it a cryſtallizable metallic ſalt. Tin is only weakly corroded by this acid, which muſt be well concentrated to produce even this corroſion. It has nearly the ſame effect upon lead. The color only of mercury, precipitated *per ſe*, is changed from a red to a yellow and a white, and by a long digeſtion to a black. It entirely diſſolves white arſenic. Laſtly, it diſſolves perfectly zinc, from the ſolution of which a fetid ſmell ariſes. This acid when treated by fuſion with metallic ſubſtances exhibits nearly the ſame phenomena, only with greater force; and with thoſe metallic matters which contain much diſengaged phlogiſton, as tin, lead, and eſpecially iron and zinc, it forms phoſphorus. Mr. Margraaf obtained a large quantity of excellent phoſphorus by diſtilling, with ſtrong heat, zinc and phoſphoric acid.

We ſhall now ſhew what effects are produced by this acid, when added to ſolutions of metals by other acids. At firſt it produces no change upon the ſolution of gold in aqua regia; but ſome time afterwards it precipitates part of the gold in its metallic ſtate. It affects the ſolution of ſilver nearly in the ſame manner, only that the quantity of ſilver thus precipitated, which reſembles ſilver precipitated by copper, is ſo ſmall, that it cannot be eſtimated. Mr. Margraaf adds, that by diſtilling to dryneſs this mixture of ſolution of ſilver with phoſphoric acid, a matter remained which did not differ from a *tranſparent luna cornea*. Nevertheleſs it was found to be not a true luna cornea, but a mixture only of ſilver with phoſphoric acid; for this matter, when placed upon a coal and heated with a blow-pipe, melted into a dark-grey glaſs. From the ſolution of mercury in nitrous acid, a copious white precipitate is formed by means of phoſphoric acid. But a ſingular circumſtance is, that this precipitate is rediſſolved, when the mixture has remained ſome time expoſed to the cold. Mr. Margraaf adds, that having diſtilled this mixture, he obtained

a considerable quantity of a white and shining mass, which by the heat of a blow-pipe was vitrified into a very transparent glass. But this circumstance seemed very extraordinary, that after he had mixed the residuum with pure lead, and cupelled this mixture, he obtained a regulus of fine silver, the quantity of which was at the rate of six drams per quintal. A white precipitate was made from a solution of lead in nitrous acid by the phosphoric acid; but this precipitate was not redissolved.

These are the properties of phosphorus, and of the phosphoric acid; most of which were discovered and ascertained by Mr. Margraaf. They shew that this acid differs no less from the marine than from other acids, and that its nature is peculiar. Mr. Margraaf, probably from the respect he has to the opinion of Stahl, does not absolutely decide that it is different from the marine acid, but he says that it certainly is not pure and crude marine acid. He thinks, that possibly it may be marine acid very intimately combined with some subtle vitrescible earth. And indeed the fixity and vitrescibility which principally distinguish the phosphoric acid, seem to shew that it contains a larger quantity of such a principle than all other acids.

The phosphoric acid seems at the same time to partake of the nature of *sedative salt* and of *white arsenic*. Sedative salt, without having very distinct acid properties, acts as in acid on many occasions. It combines with alkalis, saturates them, and reduces them to neutral salts. It is fixed in the fire, in which it melts as a vitrescent matter, like the phosphoric acid; like which also it decomposes neutral salts. *See* BORAX *and* SALT (SEDATIVE).

Arsenic is not indeed fixed, as the phosphoric acid is; and it decomposes no other neutral salt than nitre: but it is disposed to vitrification, and has a smell entirely similar to that of the phosphoric acid.

Phosphoric acid is not found solely in animal urine. Mr. Margraaf found that many vegetable matters, particularly farinaceous grains, contain enough of this acid to produce phosphorus, when they are exposed to great heat in close vessels. This acid therefore is probably formed in the vegetable and animal kingdoms, and passes from the former into the latter: but the largest quantity of it is found in urine. *See* URINE *and* SALT (FUSIBLE) *of* URINE.

Hitherto phosphorus has not been employed for any useful purpose. But we may hope that some use might be found for it, particularly if it could be made in large quantities and cheap, for its dearness has certainly prevented the proper trials and researches for this purpose. Although it were only to remain an object of curiosity, it would still be amongst the first of that kind. Many amusing experiments may be made with phosphorus, which would be more surprizing if it were less known. For instance, one may write upon a wall with a roll of phosphorus, and the writing will presently appear in letters of fire. The face, or any other object, may be covered over with phosphorus dissolved in oil, by which it is rendered luminous in a dark place, particularly if the air be heated a little. A taper may be extinguished, and instantly kindled by applying to the wick while yet hot the point of a knife, to which a piece of phosphorus has been fixed by means of suet. Finally, it is one of those substances, by which such magicians as *Comus* may perform operations which greatly surprize those who are not in the secret.

DXXXVIII. PHOSPHORIC STONES. These stones, when properly calcined, have the property of shining in the dark. The most celebrated and most anciently known phosphorus of this kind, is that called the *Bolognian stone*, from Bolognia, a city of Italy, near which this stone is found. Lemery relates, that the person who first discovered the phosphoric property of this stone was a shoe-maker, called Vincenzo Casciarolo, who used to make chemical experiments. He says that this man, walking at the foot of Mount Paterno, gathered some of these stones, the great weight and lustre of which had induced him to believe that they contained silver; and that after having exposed them to fire, and carried them into a dark place, by accident probably, he perceived the stones shining like hot coals, which much surprized him, and induced him to repeat the experiment. From that time the Bolognian stone has been operated upon by chemists and experimental philosophers, who have searched for the most advantageous method of calcining it to render it luminous.

For this purpose we find different processes in the works of La Poterie, of Montalban, of Mentzel, of Lemery, and in the Memoirs of Homberg and du Fay, printed amongst those of the Academy. But nobody has treated this matter so fully, or illustrated it so well, as the celebrated Mr. Margraaf in two Dissertations upon this subject. Wherefore, without attending to what has been said before him, we shall relate here summarily his opinion concerning the nature of Bolognian stones, his method of preparing them, the phenomena they exhibit, and the matters analogous to them; so that the whole of this article shall be extracted from the Dissertations of that able chemist.

Bolognian stone is soft, friable, heavy, crystallized, and incapable of effervescing with acids before it has been calcined in contact with fuel. These qualities have induced Mr. Margraaf to class it amongst the heavy fusible spars, and with so much more justness, as all these spars by a preparation similar to that for the Bolognian stone are rendered phosphoric. As these spars are also composed of the same principles, as we shall afterwards see, all that we shall say concerning the Bolognian stone is also applicable to all other stones of the same kind; that is, to all the heavy fusible spars, or rather to the *selenitic* spars.

When these stones are to be rendered phosphoric, such of them ought to be chosen as are the cleanest, best crystallized, most friable, most heavy, which exfoliate when broken, and, lastly, which contain no heterogeneous parts. They are to be made red-hot in a crucible, and reduced to a very fine powder in a glass mortar, or upon a porphyry. Lemery affirms, that this pulverization ought to be made in a brass mortar, and positively declares, that after many experiments, he found that the operation entirely failed, if any other, particularly an iron mortar, has been used. But Mr. Margraaf, whom we preferably follow, forbids expresly the use of a copper mortar, and affirms that it hurts the success of the operation. The stones having been thus reduced to powder, are to be formed into a paste with gum tragacanth, and divided into cakes as thin as a knife. These are to be dried by a heat, which at last is to be made pretty considerable. After these preparations, an ordinary reverberatory furnace is to be filled to three quarters of its height with charcoal, and the fire is to be kindled. Upon this charcoal the flat surfaces of the cakes are

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to rest; and more charcoal is to be placed above them, so as to fill the furnace. The furnace is then to be covered with its dome, the tube of which is to remain open; all the coal is to be consumed, and the furnace is to be left to cool. The cakes are then calcined, and are to be cleansed from the ashes by blowing with bellows upon them. When they have been exposed during some minutes to light, and afterwards carried into a dark place, they will seem to [illegible] if the stones be exposed to a stronger calcination during a full half-hour under a muffle, their phosphoric quality will be rendered stronger.

The phenomena exhibited by these stones rendered phosphoric by calcination are very worthy of attention, but are not well understood. The difficulty attending this subject, is encreased by the contradictory relations of those who have operated upon this matter, in some important facts. Mr. du Fay, who has published a Memoir concerning this kind of phosphorus in the year 1730, asserts, from experiments, that all calcareous stones, whether they contain, or not, vitriolic acid, are capable of becoming luminous by calcination; with this difference only, that the pure calcareous stones require a stronger or more frequently repeated calcination; whereas those which contain an acid, as selenites, gypsums, spars, become phosphoric by a slighter calcination. Mr. Margraaf, on the contrary, who does not seem to have known this Memoir of Mr. du Fay, says, that no other stones can be rendered phosphoric but those calcareous stones only which are saturated with an acid; that purely calcareous stones, as marble, chalk, limestone, stalactites, are incapable of receiving this phosphoric quality, till they have been previously to their calcination saturated with an acid. The cause of this phosphoric property cannot be assigned till these facts are ascertained: for if all calcareous stones are capable of being rendered luminous without the concurrence of an acid, we may then suspect that light is capable of adhering more to some bodies than to others, and that calcination gives to calcareous stones the property of retaining a larger quantity of light, and during a longer time, than other bodies can. We must nevertheless confess that this conjecture is very vague, and not much supported by facts.

But if these stones cannot be rendered luminous without the concurrence of an acid, as Mr. Margraaf thinks, and as experiments indicate; if even the acid does only contribute considerably to give them this property, as all experiments upon this matter, and even those of Mr. du Fay, seem to shew; we then have reason to believe, that acids have a considerable share in the production of this luminous property. Our conjectures upon this subject are as follow.

We know that acids in general, and particularly the vitriolic and nitrous, have a strong affinity with the inflammable principle; that when they are united with this principle, they form with it compounds possessed of the properties of sulphur or of phosphorus. We are also certain that sulphur, phosphorus, and probably other compounds of acid and phlogiston with which we are not acquainted, have each two methods of burning;

ing; the first vivid and strong, in which their phlogiston forms a very sensible flame, and produces not only light, but also so considerable a heat as to kindle combustible bodies; the other slow and weak, capable only of producing a light much less vivid, without any sensible heat, or with a heat too small to kindle combustible bodies. Such, for instance, is *gun-powder*. *See* SULPHUR, PHOSPHORUS, *and* POWDER (GUN).

This being established, may we not with probability believe, that the acid contained in stones rendered phosphoric by calcination combines with the phlogiston of the coals, forming with it a sulphureous compound; and that the phlogiston of this kind of sulphur or phosphorus adhering but weakly to the acid, or existing there perhaps only superabundantly, is very easily combustible; so that merely the action of the heat and light of the open air is sufficient to inflame it: not, however, so strongly as to produce heat and a total dissipation of the phlogiston, as when sulphur and phosphorus are burnt, but so slowly and weakly, that but a very faint light, observable only in the dark, is produced. Such is the light of the Bolognian and of other phosphoric stones of the same kind.

Several phenomena of this phosphorus seem capable of confirming this conjecture. First, the Bolognian stone, the spars and gypsums which are rendered luminous by calcination, have, according to all those who have operated upon them, a smell of sulphur after their calcination, and preserve this smell while they have the phosphoric quality.

Secondly, the calcination of these stones must be made in contact with coals, otherwise they are not rendered luminous, as Mr. Margraaf has observed. But we are certain that this is one of the conditions necessary for the production of all sulphurs, and of phosphorus of all kinds: and as this calcination is also made with the concurrence of the air, and succeeds better in this manner than in close vessels, the sulphureous compound formed in this operation is probably in a state of inflammation and combustion during the calcination, which gradually diminish as the stone cools, so as to be rendered insensible by means of the great quantity of incombustible stoney matter with which the sulphureous compound is covered and surrounded on all sides: the combustion, however, does not so entirely cease, but that merely the action of light is capable of renewing and encreasing it, so as to render it sensible in the dark.

Thirdly, Mr. Margraaf has observed, that every phosphorus of that kind which requires to be exposed to light in order to make it shine in the dark, may, without any such exposure, during two or three days or [illegible]m, be rendered very luminous merely by being heated; that is, by [illegible] substance, which is at the same time incapable of giving light [illegible] stance, a plate of iron heated, so [illegible] least redness even in the dark. This curious experiment shews very clearly, that the phosphoric lig[illegible] proceeds from a very weak and slow inflammation, which is so checked by cold, that no sensible light proceeds from it, even in the dark, but which may be encreased and renewed by a very weak heat. This matter might be further illustrated by observing the effects of exposing this phosphorus to a great degree of cold at the time of its being very luminous. We should probably find that its light would be gradually diminished, and at length extinguished by the cold.

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Thus we have strong reasons to believe, that the light of all these phosphoric stones is nothing but a very slow and weak combustion or inflammation of a certain quantity of phlogiston which they contain.

Many facts may indeed be objected to this opinion. 1. If the light of this phosphorus was only the effect of a true inflammation, it could not take place without the free access of air, and it would be extinguished, like that of other inflamed substances, when phosphorus is immersed in water or any other liquid. But we are certain that these phosphoric stones have the same effects when they are kept in bottles hermetically closed, or even when immersed under water, as Mr. de Fay has shewn. 2. Mr. de Fay found by experiments, that stones purely calcareous, and containing no acid, are nevertheless rendered phosphoric by calcination. But no sulphureous or phosphoric compound can be formed in these stones. Their light therefore does not seem to depend on any inflammation.

To these objections we may answer, that although in general inflammable bodies cannot burn with access of air, this rule is not however free from exceptions, in the instances of sulphureous and phosphoric compounds, particularly concerning that kind of inflammation which is weak and incapable of kindling other combustible matters, which must be carefully distinguished from their rapid combustion, as we have already remarked. We are certain that this weak and slow inflammation of such bodies may subsist without access of air, or at least with much less air than is necessary for the other inflammation, and proportionable to its weakness. We cannot doubt that the light proceeding from the phosphorus of urine is an effect of a weak combustion of this phosphorus, as may be seen under the article PHOSPHORUS *of* KUNCKEL. But this light is well known to appear in water, in oil, in the best closed glass vessels, to encrease by heat and to diminish by cold, which also happens to the phosphoric stones. Besides, although these stones may shine as well as phosphorus in water and in vessels perfectly close, their light is still weaker than in open air, and is much more quickly extinguished in water or other liquors than in air, according to the experiments of Mr. du Fay. In this respect then they are entirely similar to the phosphorus of urine: perhaps even ordinary sulphur heated, and properly treated, might exhibit the same phenomena (*b*).

(*b*) I doubt whether a phosphorus could be made of sulphur without addition of quicklime or other substance, to which the vitriolic acid has a disposition to unite. For the principal cause of that slow combustion which produces phosphoric light, seems to be, that the union between the acid and the phlogiston of such phosphoric substances, is weakened by the presence of some earth to which the acid has also a disposition to unite; and that the phlogiston is thereby gradually disengaged, especially when it is in contact with air, to which it is at all times strongly disposed to unite, as we may perceive from the necessary concurrence of that fluid to maintain ordinary combustion, which is only a more rapid and copious disengagement of phlogiston from the burning substances. Accordingly, if we examine the several kinds of phosphorus, we shall find that each of them consists of an acid, an earth, and phlogiston. From Mr. Margraaf's experiments we find that the Bolognian and other phosphoric stones contain a selenites, or a calcareous earth united with vitriolic acid, and that the phlogiston is given to them during calcination. The phosphorus of urine contains also an acid and phlogiston. But from the experiments of the same excellent chemist we find, that this acid is always united with a peculiar earth. The phosphorus of Homberg is a combination of marine

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In the second place, (as to Mr. du Fay's aſſertion, that calcareous ſtones bec me phoſphoric by calcination, we may obſerve, that as he did not examine chemically the ſtones he employed, and made no experiments to determine whether they contained any vitriolic acid or not, we cannot be certain that they did not contain any. For we know, that many of the ſtones which ſeem to be entirely calcareous, do however contain more or leſs of gypſeous or ſelenitic ſubſtances. Of this kind, perhaps, the ſtones employed by Mr. du Fay might be. Beſides, if we ſuppoſe that theſe ſtones contained no acid nor ſulphur, perhaps they are capable of retaining ſome of the phlogiſton of the coals in the calcination, and we may eaſily conceive that this phlogiſton alone is capable of producing a phoſphoric quality. Laſtly, we are certain, even from Mr. du Fay's experiments, that pure calcareous ſtones become much leſs luminous by calcination than thoſe which contain an acid, and are rendered phoſphoric much more difficultly.

After all that we have ſaid concerning phoſphoric ſtones, we ought to underſtand them clearly. The *phoſphorus of Baldwin* and the *phoſphorus of Homberg* are exactly ſimilar to thoſe made with the Bolognian ſtone and phoſphoric ſpars, from which they differ only in the kind of acid which they contain.

The *phoſphorus of Baldwin* is a combination of chalk with nitrous acid; and the *phoſphorus of Homberg* is a combination of quicklime with the acid of ſal ammoniac. The former is therefore a nitre with calcareous baſis, and the other a marine ſalt with calcareous baſis. They acquire the phoſphoric property by calcination, as well as the Bolognian ſtone and ſpars do, which are vitriolic ſalts with baſis of calcareous earth. Theſe two matters are not to be calcined in contact with fuel, but in crucibles. The phoſphorus of Baldwin receives its phlogiſton from the nitrous acid; chalk alſo contains ſome phlogiſton. The phoſphorus of Homberg receives its phlogiſton from the ſal ammoniac which is treated with quicklime.

As the nitrous and marine ſalts with earthy baſes are deliqueſcent, they attract the moiſture of the air after they have been dryed, and even after they have loſt ſome of their acid by calcination; for which reaſon they cannot be preſerved but in veſſels accurately cloſed, and their phoſphoric quality laſts much ſhorter time than that of ſpars. The theory of theſe two kinds of phoſphorus ſeems to be exactly the ſame as that of phoſphoric ſtones. *See* SPAR.

DXXXIX. PINCHBECK. *See* BRASS *and* SIMILOR.

DXL. PITCH. (*i*)

rine acid with calcareous earth, which abſorbs phlogiſton from the burning fuel during its fuſion. The phoſphorus of Baldwin is a ſimilar combination of nitrous acid with calcareous earth; and the pyrophorus of Homberg is a combination of vitriolic acid, earth of allum, and the phlogiſton of flour, or other inflammable ſubſtance.

(*i*) PITCH. When the wood of pines, firs, and other trees, from which turpentine is obtained, is expoſed to fire in veſſels which have openings only at their bottoms, as, for inſtance, in an inverted retort, the reſinous and other juices melt out by the heat, and at the ſame time acquire an empyreumatic ſmell and taſte. This is *tar*, which being boiled, exhales much acid phlegm and eſſential oil, and becomes thick. It is then changed into *pitch*. Pitch and tar conſiſt chiefly of the reſinous, but contain alſo much of the gummy, ſaline, and earthy matter of the wood. Hence they are not much diſpoſed to unite with oils and fats, and hence too they are gradually corroded by air and moiſture, when employed to preſerve wood, and other ſubſtances; as ſhips, caſks, ſhingles,

DXLI. P I T C H (M I N E R A L). (*k*)

DLXII. P L A N T S. *See* Kingdom (Vegetable).

DXLIII. P L A S T E R. *See* Gypsum.

DXLIV. P L A T I N A. Platina is a perfect metal, analogous with the perfect metals, especially with gold, as many properties are common to both.

Although metals, from their great utility, have been always diligently searched for, yet this has remained undiscovered till lately, which is a very surprising circumstance, and which seems to prove that platina is not, like the other metals, scattered in different parts of the world, and in all climates. Platina is found in the golden mines of Spanish America, and chiefly in those of Santa Fé near Carthegena, and in the Bailliwick of Choco in Peru.

This metal was probably known to the workers of these mines long before it was brought into Europe: but as its color is not very fine, and as it is almost intractable, especially by fusion, without addition, they seem to have neglected it, considering it as some refractory mineral or marcasite: some of them, however, had attempted to melt it, and to make toys of it, as tobacco-boxes and other things of that kind; but this must certainly have been by allaying it with other metals, as we shall soon see the impossibility of their doing it otherwise.

Nevertheless, this metal continued to be so neglected, that it was entirely unknown in Europe till Don Antonio Ulloa, a Spanish mathematician, who accompanied the French academicians sent by the King of France to Peru to determine the figure of the earth by measuring a degree of the meridian, first mentioned it in the relation of his voyage, printed at Madrid in the year 1748: but he says little of it, and represents it as an intractable metallic stone, which impeded the extraction of gold from the ore when it was in a large quantity. This account was not very likely to excite the curiosity of chemists concerning a new perfect metal, and a matter so interesting and surprising as they afterwards found it to be.

But before that time, that is, in 1741, an English metallurgist, called *Wood*, who had brought from Jamaica some specimens of it, which he was informed had come from Carthagena, attended more to it, and made some good chemical trials

shingles, &c. To render them more durable, and less liable to be melted by the heat of the sun in summer, an anonymous author advises that tar should be mixed when boiling-hot with coal-dust, in such quantity as to render it thick; by which preparation, he says, tar is fixed, never runs, bends and hardens surprizingly from heat and moisture.

From two ounces of pitch, one ounce and half a scruple of resinous matter were extracted by spirit of wine. Half an ounce of empyreumatic oil separated during the digestion, and nearly half an ounce of earthy matter remained, from which water extracted nothing. The same quantity of the same pitch, boiled first in water, yielded two drams and half a scruple of gummy extract.

Eight ounces of pitch distilled in an open fire yielded two ounces one dram and a half of an acid spirit, and two ounces five drams of a fetid oil, three ounces of a shining black coal remaining in the retort. *Neuman.*

(*k*) Pitch (Mineral). This is a fetid, black, thick, and tenacious bitumen, differing from petroleum in having a thicker consistence and a darker color. Petroleum, exposed to evaporation, deposites a substance similar to mineral pitch. It is used for the same purposes for which pitch and tar are applicable.

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of it. Since that time, ſeveral chemiſts, the chief of which are M. Scheffer, of the Swediſh Academy, and Dr. Lewis, of the Royal Society of London, have very particularly examined this ſingular metal, and have publiſhed their experiments. Dr. Lewis has in ſome meaſure exhauſted this matter, in four excellent memoirs communicated to the Royal Society. Platina was, nevertheleſs, little known in France till the year 1758, when Mr. Morin, zealous for the progreſs of ſcience, collected, tranſlated into French, and publiſhed an account of all that had hitherto been done upon platina, in a work entitled, *Platina, White Gold, an eighth Metal.*

This publication excited the curioſity of French chemiſts, to whom it was a new and intereſting object; but the difficulty of obtaining a matter ſo dear prevented all of them from being able to ſatiſfy their deſire of examining it. Meſſrs. Macquer and Beaumé were the only perſons who made experiments upon it, which they have publiſhed amongſt the Memoirs of the Academy for the year 1751.

About the ſame time alſo, Mr. Margraaf examined platina, and publiſhed a diſſertation concerning it.

Theſe are the only chemiſts who have examined, at leaſt, who have publiſhed their reſearches concerning this new metal. But although their number be ſmall, yet their experiments are ſo numerous, made with ſuch accuracy, and in general ſo conſiſtent with each other, that by collecting and comparing them, we may acquire as certain and almoſt as extenſive knowledge of platina as of the other metals that have been known from time immemorial. This article ſhall contain the moſt general and certain reſults of the experiments made by the above-mentioned chemiſts.

Platina, a Spaniſh word, is a diminutive of *plata*, which in that language ſignifies ſilver. It is therefore called by the Spaniards *little ſilver*. This name is improper, ſince it reſembles ſilver only in being indeſtructible, and very imperfectly in its color. The name of *white gold*, given to it by ſome chemiſts, is more ſuitable; for we ſhall ſee that it reſembles gold more than any one metal reſembles any other; and hence we ſhall chiefly compare it to gold.

We do not certainly know the origin and natural hiſtory of platina. We can only aſſert, that all that we ſee in maſſes, or worked into forms, is not pure nor in its natural ſtate; for we are certain that it is unfuſible, without addition, by the moſt violent fire of our furnaces. All the platina that is found in the cabinets of curious perſons conſiſts of ſmall angular grains, the corners of which are a little rounded. It is mixed with a conſiderable quantity of ſmall black ſand, as attractable by magnets as the beſt iron, but inſoluble by acids, unfuſible, and untractable. This ſand is perfectly ſimilar to that which is found at St. Quay in Bretagne. The grains of platina are alſo frequently interſperſed with particles of ſpar and of quartz, and ſometimes with ſpangles of gold. Meſſrs. Macquer and Beaumé found a pretty large ſpangle of gold in the platina examined by them. But theſe heterogeneous matters are quite foreign to platina, and are not combined with it; for it contains nothing extraneous excepting a little gold and mercury, which latter ſubſtance it probably receives during the operations for extracting gold from the ore by means of mercury. Theſe matters may eaſily be ſeparated from the platina without decompoſing it, by waſhing and by magnets. Some chemiſts, who know

platina

platina only by name, and deny that it is a peculiar metal, have therefore, with great impropriety, advanced, that Mr. Margraaf had decompofed it, and had obtained from it gold, iron, and arfenic. The contrary appears from Mr. Margraaf's Differtation. Mr. Margraaf only feparated the heterogeneous matters which were merely mixed with platina, as other chemifts have done; but he is too good a chemift to pretend that he has decompofed it: on the contrary, he does not hefitate to call it a *perfect metal*, which name is alfo given to it by all who underftand metals.

The color of the grains of platina is metallic, white, livid, not very brilliant, intermediate betwixt the white of filver and the grey of iron. At firft view they refemble large filings of iron. They are fmooth, and are nearly as hard as iron; they are fomewhat ductile; fo that fome of them may be flattened upon an anvil, while others are bruifed into fmall pieces.

The fpecific gravity of platina is very great, and nearly equal to that of gold. In water it lofes only fomething betwixt an eighteenth and a nineteenth part of its weight.

The tenacity of the parts of this metal has not been determined, becaufe it cannot be formed into a proper figure to make the experiment. But if this quality is proportionable to the ductility and hardnefs of metals, we may prefume, that as platina is much harder than gold, its tenacity is alfo greater, if all the ductility of which it feems fufceptible could be given to it by art.

Platina is, like pure gold and filver, free from all fmell and tafte. It is unalterable by the combined action of air and water, and is no more fufceptible than the other perfect metals of acquiring ruft. Like them alfo, it is indeftructible by the moft violent and long continued fire: but the property which peculiarly diftinguifhes this metal is its infufibility by the moft intenfe heat.

As fufion is neceffary for the application of metals to ufe, chemifts have made their utmoft efforts to melt platina. The moft violent heat which could be raifed in air-furnaces, or by the united action of feveral large bellows, has been applied repeatedly, and continued a long time without fuccefs. In all thefe trials the grains of platina remained unaltered in form and weight, and were only agglutinated to each other, nearly as fand is by expofure to violent heat, but fo flightly, that by the fmalleft effort they were feparable. Meffrs. Macquer and Beaumé expofed platina during five days and five nights to the greateft heat of a glafs-houfe furnace, which trial did only confirm the unfufibility and unalterability of platina by ordinary fires, as it was found to be only a little agglutinated, and its weight to be a little encreafed; which latter phenomenon has been alfo obferved by Mr. Margraaf. Laftly, Meffrs. Macquer and Beaumé, having expofed platina to the focus of a large burning-glafs, melted a little of it in a minute. It firft fmoked, then emitted fparks, and thofe parts of it melted well which were expofed to the center of the focus. Thefe chemifts carefully examined the properties of this platina. According to their memoir, the melted parts were diftinguifhable from the others by a brilliancy like that of filver, and by a rounded, fhining, polifhed furface. They were eafily flattened upon an anvil, and formed into very thin plates without cracking or fplitting; fo that thefe grains feemed to be much more malleable than platina in its natural ftate. Thefe metals by repeated ftrokes of the hammer become hard and brittle, as all other metals do, particularly gold and filver;

ſilver; and by annealing, their malleability was reſtored, as it is alſo to other metals by the ſame means. After experiments ſo certain and well authenticated, we cannot doubt that platina is truly a metal, and even a third metal, as perfect in its kind as gold and ſilver are in theirs. This propoſition will be further confirmed by the other properties of platina.

Platina reſiſts as perfectly as gold the action of the vitriolic, marine, or nitrous acids; in a word, of any pure acid, in whatever manner applied. Theſe acids, concentrated or diluted, may be boiled any length of time upon platina without diſſolving an atom of it: but a mixture of nitrous and marine acids, aqua regia, the ſolvent of gold, is alſo the ſolvent of platina. Meſſrs. Macquer and Beaumé have obſerved, that an aqua regia compoſed of equal parts of the two acids diſſolves moſt of this metal. But, however the aqua regia is made, more of it is required to diſſolve platina than gold. Theſe chemiſts employed a pound of aqua regia to diſſolve an ounce of platina. All the acid of this quantity of aqua regia was not indeed employed to diſſolve the platina, becauſe much of it was diſſipated in vapors during the operation, from the long time employed in the ſolution; and therefore if the operation had been performed in cloſe veſſels, and by diſtillation and cohobation, as Dr. Lewis did, a leſs quantity of aqua regia would have been ſufficient: but this is a matter of ſmall importance.

Aqua regia requires to be aſſiſted by the heat of a ſand-bath, and alſo a conſiderable time, to diſſolve platina well. Although the color of this metal is white, its ſolution is very yellow, even deeper than that of gold. When a ſmall quantity of platina only is diſſolved in aqua regia, or when a ſaturated ſolution is much diluted, a beautiful yellow color is produced, undiſtinguiſhable from that of a ſolution of gold: but while the aqua regia becomes more and more ſaturated with platina, its color becomes more and more intenſe, and at laſt red; but this apparent redneſs evidently proceeds from nothing but the intenſity of the yellow color; for this ſaturated ſolution is rendered yellow by dilution with water. In this circumſtance it is ſimilar to tincture of ſaffron.

The ſolution of platina in aqua regia is acid and corroſive, and from it a neutral cryſtallizable ſalt may be obtained. When the acids employed are concentrated, and when the ſolution is nearly ſaturated, a confuſed cryſtallization is formed at the bottom of the matraſs, which may be found to be a heap of very ſmall, yellow, tranſparent cryſtals. Theſe cryſtals of platina may be obtained much larger and more beautiful by evaporating the ſolution of platina with a very ſlow fire, and by cooling it very ſlowly. I found that the ſolution of platina tinged the ſkin and other animal matters with a blackiſh brown color, in certain circumſtances (in which reſpect it reſembles the ſolutions of gold, ſilver, and of mercury), and that ether mixed with this ſolution by agitation quickly ſeparates from it, and becomes tinged with a fine yellow color, preciſely as it does when it is treated in the ſame manner with a ſolution of gold. This experiment ſhews, that ether, and probably other attenuated oily matters, take platina, as they do gold, from aqua regia; and hence we may perceive another inſtance of the conformity of theſe two metals. But as ether does not acquire nearly ſo intenſe a color as the ſolution of platina, we may infer that it only receives a ſmall quantity of this metal. Beſides, the platina ſoon ſeparates ſpontaneouſly from the ether.

Platina may be precipitated from its ſolvent by fixed and volatile alkalis *(l)*; and theſe precipitates are all of a yellow brick-color, when only ſo much alkali is employed as is neceſſary to ſaturate the acid of the ſolution; but are of a paler color when a ſuperabundant quantity of alkali is employed, or when they are digeſted in alkali. Theſe colors of precipitates of platina proceed from a large quantity of ſaline matters which precipitate along with them, and which ſtrongly adhere to them, and not from any calcination of this metal, or loſs of its phlogiſton. The proof of this is, that if the cryſtals or precipitates of platina be expoſed to ſtrong heat, the ſaline matters which adhere to them are expelled, the color occaſioned by them is loſt, and the platina recovers without any addition its ordinary metallic ſtate.

All the above-mentioned phenomena exhibited by platina treated with acids and alkalis are ſimilar to thoſe which gold exhibits in ſimilar circumſtances: but platina has alſo in this reſpect ſome peculiar properties by which it differs from gold. 1. The ſolution of platina acquires a deeper color than that of gold. 2. The precipitate of platina made by volatile alkali does not fulminate as that of gold does. 3. Tin does not produce from the ſolution of platina a purple precipitate, capable of tinging glaſs, as it does from a ſolution of gold.

Neither nitre, which quickly and effectually calcines all imperfect metals; nor corroſive ſublimate, the acid of which, being very much concentrated, acts upon almoſt all metals; nor any other neutral ſalt, could occaſion the ſmalleſt alteration upon platina or upon gold.

This ſingular metal reſiſts, as well as gold does, the action of ſulphur, which ſo powerfully diſſolves other metals. From Dr. Lewis's experiments we find, that liver of ſulphur is capable of diſſolving platina, as it does alſo gold, by fuſion. Mr. Margraaf's experiments leave this matter uncertain: but if, as we have reaſon to believe, liver of ſulphur does diſſolve platina, this is another inſtance of the conformity of this metal with gold.

Almoſt all metallic ſubſtances are capable of ſeparating platina from aqua regia, as they alſo ſeparate gold. Platina precipitated by theſe ſubſtances has its metallic appearance. In this reſpect it conforms with a general rule, that metals precipitated by other metals have their metallic appearance. *See* PRECIPITATION.

Mr. Margraaf relates, in his Memoir, a great number of experiments which he made to diſcover the effects of mixing a ſolution of platina with other metallic ſolutions, and alſo of digeſting pure platina with theſe ſolutions and other ſaline ſubſtances. Theſe experiments furniſhed many curious and intereſting facts; but as ſeveral of them do not ſeem to be conſiſtent with the eſſential and aſcertained properties of platina, nor even with ſimilar experiments made by other chemiſts, we have reaſon to believe that theſe ſingularities obſerved by this able chemiſt proceeded from ſome extraneous matters with which his platina was allayed.

(l) Mr. Margraaf mentions a very ſingular fact concerning the precipitation of platina by alkalis; namely, that although vegetable fixed alkali, and even volatile alkali, precipitated this metal from aqua regia; yet the mineral alkali, though in other inſtances equal in power of union to the former alkali, and ſuperior to the latter, produced no precipitation, even when ſo much of it was added as to ſaturate the acid, nor even diſturbed the tranſparency of the liquor.

allayed. From moſt of theſe experiments, as, for inſtance, from the yellow flowers obtained by ſubliming platina with ſal ammoniac, and from the blue precipitate formed by mixing his ſolution of platina with a lixivium of Pruſſian blue, we may conclude, that iron was the metal with which his platina was allayed, as he himſelf ſays.

Platina, like gold, is capable of being allayed with all metals, and in theſe allays exhibits intereſting phenomena. Dr. Lewis has examined theſe allays more carefully and fully than any other perſon. As we have ſaid nothing of it under the article Allay, we ſhall ſummarily mention here what Dr. Lewis has obſerved on this ſubject.

Platina, although very unfuſible when alone, may however be fuſed along with other metals with which it is capable of combining. Equal parts of gold and platina may be melted in a violent fire, and the allay which is formed may be eaſily poured into an ingot mould. It is whitiſh, hard, and may be broken by a violent blow. Nevertheleſs, when it has been well annealed, it is capable of conſiderable extenſion under the hammer. One part of platina and four parts of gold may be melted and allayed with a much leſs fire than is requiſite in the preceding experiment. This allay is ſo ductile, that it may be extended into very thin plates without being broken, or even ſplit at the edges. Dr. Lewis obſerved a remarkable circumſtance concerning this allay, namely, that the platina, which was $\frac{1}{5}$ of the whole maſs, rendered the gold no paler than guineas are, which contain only $\frac{1}{12}$ of ſilver.

Silver and platina may be melted and allayed together in equal parts with a very violent fire. The allay which is formed is much harder and darker-colored than ſilver, and of a large grain, although it preſerves ſome ductility. Theſe qualities are leſs ſenſible when one part of platina is added to ſeven parts of ſilver: but this allay is ſtill coarſer-grained and leſs white than ſilver. This coarſeneſs of grain ſhews an imperfect union; and indeed ſilver and platina do not ſeem to unite very intimately; for Dr. Lewis obſerves, that when the allay of theſe two metals was left after fuſion in the crucible, a conſiderable part of the platina was ſeparated and ſunk to the bottom. The platina did not appear to communicate any good quality to the ſilver, excepting a greater hardneſs.

Copper ſeems to be moſt improved by being allayed with platina. When indeed a large proportion of platina is added to copper, as equal parts or two-thirds, the allay is hard, brittle, and coarſe: but when a leſs quantity of platina is added, as from $\frac{1}{6}$ to $\frac{1}{24}$, or even leſs, a golden-colored copper is produced, very malleable, harder, ſuſceptible of a finer poliſh, ſmoother-grained, and much leſs ſubject to calcination and ruſt than pure copper.

Dr. Lewis was not able to fuſe forged iron with platina, which is not ſurprizing, when we conſider the refractory qualities of theſe two metals: but he allayed platina with caſt-iron, by throwing one part of platina to four parts or more of the iron when it was juſt beginning to flow. This allay was much harder, and much leſs ſubject to ruſt, than pure iron. It was ſuſceptible of a very fine poliſh.

Platina may be melted with tin in all proportions from equal parts of the two metals to twenty-four parts of tin. This allay was obſerved to be ſo much harder, more brittle, more dark-colored, and coarſer, as the proportion of the platina

platina was larger. No advantage seemed to be acquirable by this allay. Lead also may be allayed in different proportions with platina, nearly as tin may, with this difference, that a much greater fire is necessary for the formation of this latter allay, particularly when the quantity of platina is great. The metal resulting from it has a dark color, somewhat approaching to a purple or violet, or it easily acquires these colors when exposed to the air. When the two metals fused together are left in a crucible to cool, a considerable part of the platina separates and falls to the bottom, in the same manner as it does from the allay of silver.

From Dr. Lewis's experiments platina appears to be capable of amalgamating with mercury, but difficultly, and by a very long trituration with water, as, for instance, during a week.

If mercury be triturated with an allay of gold and platina, it seizes the gold, and does not touch the platina. Dr. Lewis proposes this amalgamation as a method of separating these two metals; and it is that which is employed in the ores of Peru, in which gold and platina are mixed together: but we do not yet know whether this separation be perfectly complete.

Platina may be allayed with bismuth nearly as with lead, and in a similar manner separates from the bismuth after fusion. It gives to bismuth also, as it does to lead, the property of acquiring, by exposure to air, violet, purple, or blue colors. This allay is always very brittle.

Of all metallic matters zinc may be most easily allayed with platina, and most effectually dissolved by fusion. Dr. Lewis observed, that these allays did not appear very different from pure zinc; but that when the proportion of platina is considerable, their grain is closer, their color less clear, and more bluish than of zinc. They do not tarnish, nor change colors, by exposure to air. Lastly, they are harder than zinc, and have not the semi-malleability of this semi-metal.

With regulus of antimony platina formed a darker and harder compound than the pure regulus.

Dr. Lewis has combined platina at the same time with two metallic matters, such as with brass composed of copper and zinc, and with bronze composed of copper and tin. The most singular phenomenon of this latter allay was, that the copper and tin acting conjointly upon the platina was capable of dissolving more of it than they both could do separately. This allay was hard and capable of receiving a fine polish, but is subject to tarnish, which seems to happen to all the allays of tin or of lead with platina.

Equal parts of platina and brass formed a compound very hard and very brittle, capable of receiving a very fine polish, and not subject to tarnish. It might therefore be employed for speculums of telescopes, and would be much preferable to those now used, all which have the great disadvantage of tarnishing by exposure to air, and even very quickly.

Dr. Lewis does not mention the effects of allaying platina with arsenic; but Mr. Scheffer affirms, that if only a twentieth part of arsenic be added to platina when red-hot in a crucible, these two substances will be perfectly fused, and will form a brittle, grey mass. This remarkable experiment requires confirmation: for Mr. Margraaf having also treated these two matters together, did not perceive any such action of arsenic upon platina. From one of his experiments

we find, that having expofed to a violent fire during an hour a mixture of an ounce of platina with a fufible glafs compofed of eight ounces of minium, two ounces of flints, and one ounce of white arfenic, he obtained a regulus of platina, well united and fufed, which weighed an ounce and thirty-two grains, the furface of which was fmooth, white and fhining, and the internal parts grey, but which neverthelefs appeared fufficiently white when it was filed.

The cupellation of platina was one of the moft important experiments to be made; becaufe if this operation fucceeded perfectly, we might thereby obtain compact and malleable maffes of pure platina, in the fame ftate as a metal which had been well fufed, and of which all forts of utenfils might be made, if not by cafting it, at leaft by forging. All the chemifts who have examined this metal, and particularly Dr. Lewis, have ufed their utmoft endeavours to cupel it well. But although they have ufed every expedient to apply the ftrongeft heat, they have not perfectly fucceeded. The fcorification proceeds well at the beginning of the operation, as when gold and filver are cupelled: but the cupellation afterwards becomes more and more difficult; becaufe, as the quantity of lead diminifhes, the matter becomes lefs and lefs fufible, and at laft ceafes to be fluid, notwithftanding the moft violent heat; and alfo becaufe, when the quantity of platina is greater than that of the lead, this latter metal is protected, and is not converted into litharge. Hence the regulus obtained is always dark-colored, rough, adhering to the cupel, brittle, and weighing more than the platina originally employed, from the lead which remains united with it. Meffrs. Macquer and Beaumé appear neverthelefs to have carried this experiment further than any other chemifts, as they kept the matter expofed to a violent fire during a longer time, that is, about fifty hours fucceffively; therefore, although their platina was tarnifhed and rough on its furface, it was internally white and fhining, eafily feparable from the cupel, and a little diminifhed in weight, a certain proof that no lead remained in it. This platina was alfo ductile, and capable of extenfion under the hammer. Cupellation is therefore a certain method of applying platina to ufe, and of forming it into utenfils.

The fciences, commerce, and arts muft receive great advantages from the application of a new perfect metal to ufeful purpofes, which to the fixity and indeftructibility of gold unites a hardnefs and folidity almoft equal to thofe of iron; which is unalterable by the action of water and air; is not fubject to ruft; and refifts as well as glafs or earthen veffels all falts, even aqua fortis and other pure acids. We regret, that although large quantities of it are found in America, it is fo exceedingly rare here.

The caufe of this great fcarcity of platina is, that the Spanifh Miniftry have prohibited the fale of it, or the extraction of it from the mines. Thefe prohibitions were certainly from good motives and wife intentions; for this metal was no fooner known than it was employed for the adulteration of gold, for which purpofe it is very fit, as it fuftains all the ordinary trials of gold, has the fame fpecific gravity, and renders gold much lefs pale than filver. The ufe of a metal with which frauds fo prejudicial might be committed with impunity was neceffarily interdicted: but fince the beft chemifts of Europe have examined platina, they have publifhed certain and eafy methods by which the fmalleft quantity of platina mixed with gold may be difcovered, and by which thefe

metals

metals may be separated, in whatever proportion they may happen to be united. These methods may be seen in the Memoirs of the chemists who have examined this matter. We shall here relate only one of the most convenient and least troublesome. It is founded on a property which gold has, and not platina, of being capable of precipitation from aqua regia by martial vitriol; and upon a property which platina has, and not gold, of being capable of precipitation from aqua regia by sal ammoniac. When therefore we would discover if gold be allayed with platina, let it be dissolved in aqua regia, and to this solution, which will contain both metals, let some sal ammoniac dissolved in water be added, upon which the platina will be precipitated in form of a brick-colored sediment. If, on the other side, we would know if platina contained any gold, let this platina be dissolved in aqua regia, and to the solution add a solution of martial vitriol in water, upon which the liquor will become turbid, and the gold will form a precipitate which may be easily separated by decanting and filtrating the liquor.

We may then affirm, that the reasons which induced the Spanish Ministry to interdict the use of platina no longer subsist; and we hope that when they are once convinced of this, society shall no longer be deprived of a substance which may be so advantageous to them, and which may be a new source of wealth to the Crown of Spain, the sole proprietor of this precious treasure.

DXLV. PLUMBUM CORNEUM. This is a combination of lead with marine acid. It is a metallic salt which may be made by combining directly lead with that acid: but this process is not much used, because others are more convenient. For instance, by pouring some marine acid, or the solution of a salt containing it, into a solution of lead made by the nitrous acid, we obtain a plumbum corneum, which falls down to the bottom of the vessel, if the liquor does not contain too much water. A similar combination may be made by distilling calxes of lead, as minium, for instance, with sal ammoniac. The lead disengages the volatile alkali of this salt, and unites with its acid, which is the same as that of common salt.

Lead united with marine acid has some resemblance to luna cornea, which is a combination of silver with the same acid; and hence has been called plumbum corneum. Like the luna cornea, it is semi-volatile and crystallizable, but is infinitely more soluble in water. This combination is not used in the arts, and little in chemistry. *See* LEAD.

DXLVI. POMPHOLIX. This is one of the names given to the flowers of zinc sublimed during the deflagration of this semi-metal. *See* FLOWERS *of* ZINC *and* ZINC.

DXLVII. PORCELAIN. Porcelain is the most beautiful and finest of all earthen wares. All earthen wares which are white and semi-transparent are generally called porcelains: but amongst these so great differences may be observed, that notwithstanding the similarity of their external appearance, yet when they are examined chemically, they cannot be considered as matters of the same kind. These differences are so evident, that even persons who are not connoisseurs in this way prefer much the porcelain of some countries to that of others.

As the several kinds of porcelain differ so much from each other, no general process can be given for making it. We ought therefore to confine ourselves

to describe and consider the manufacture of some particular porcelain, remarkable for its excellence and beauty. But this also is almost impracticable; because in all the manufactories where it is made, both in France and other countries, the ingredients and method of preparation employed are carefully concealed. Nevertheless, we have a general knowledge of the principal operations of this manufacture, which we shall here deliver; and that we may supply the details which we cannot describe, we shall give our opinion concerning the qualities which the best porcelain ought to have. This seems to be necessary, as the manufacture of porcelain is an object more attended to than ever; and as many persons, otherwise intelligent, talk and judge of it without having any precise notions on the subject.

The art of making porcelain is one of those in which Europe has been excelled by oriental nations. The first porcelain that was seen in Europe was brought from Japan and China. The whiteness, transparency, fineness, neatness, elegance, and even the magnificence of this pottery, which soon became the ornament of sumptuous tables, did not fail to excite the admiration and industry of Europeans. I shall not here relate the histories of the several attempts made in Europe to imitate the oriental porcelain, as most of them are unknown, and would lead us too far from the subject. I shall only say, that in different parts of Europe, earthen wares have been made so like the oriental that they have acquired the name of porcelain. Neither shall I inquire into the æra of the establishment of the several manufactures of porcelain in Europe. I shall only say, that I believe the first European porcelains were made in Saxony and in France; and afterwards in England, Germany, and Italy. But as all these were different from the Japanese, so each of them had its peculiar character.

We now proceed to determine the quality of the principal porcelains, namely, those of Japan or of China, of Saxony and of France.

The illustrious Reaumur first attended to this object, and communicated his researches in two Memoirs before the Academy of Sciences in 1727 and 1729. This great experimental philosopher took the best method of arriving at a thorough knowledge of the subject; and although he was mistaken in some points, and altho' he neglected to consider some of the essential qualities requisite to constitute good porcelain, he is nevertheless the first person who published any distinct notions upon the subject. He did not satisfy himself with considering the external appearance, the painting and gilding, which are only ornaments not essential to the porcelain, but he endeavored to examine it internally: And having broken pieces of the Japanese, Saxon, and French porcelains, he examined the difference of their *grains* (which name is given to their internal structure). The grain of the Japanese porcelain appeared to him to be fine, close, compact, moderately smooth, and somewhat shining. The grain of the Saxon porcelain was found to be still more compact, not granulous, smooth, shining like enamel. Lastly, the porcelain of St. Cloud had a grain much less close and fine than that of Japan, not, or but little shining, and resembling the grain of sugar.

From these first observations Mr. Reaumur perceived that porcelains differed considerably. That he might examine them further, he exposed them to a violent heat. More essential differences than those of the grain appeared upon this

this trial; for the Japanese porcelain was unaltered by the fire, and all the European were melted, as Mr. Reaumur says.

This essential difference betwixt the Japanese and European porcelains suggested to Mr. Reaumur a very ingenious thought, and in many respects true, concerning the nature of porcelain in general. As all porcelains somewhat resemble glass in consistence and transparency, tho' they are less compact and much less transparent, Mr. Reaumur considered them as *semi-vitrifications*. But every substance may appear, and may actually be in a semi-vitrified state in two manners: for, first, it may be entirely composed of vitrifiable or fusible matters; and in this case, by exposing it to the action of fire, it will be actually melted or vitrified, if the heat be sufficiently strong and long-continued. But as this change is not made instantly, especially when the heat is not very violent, and as it passes through different stages or degrees, which may be more easily observed as the heat is better managed; hence, by stopping in proper time the application of heat to porcelain made in this manner, we may obtain it in an intermediate state betwixt those of crude earths and of completely vitrified substances; and also possessed of the semi-transparency and of the other sensible qualities of porcelain. We know also, that if such porcelain be exposed to a stronger degree of fire, it will then be completely fused and entirely vitrified. But most of the European porcelains have this fusibility, from which Mr. Reaumur concludes, that their composition is founded upon the above-mentioned principle.

In the second place, a paste of porcelain may be composed of fusible and vitrifiable matter, mixed with a certain proportion of another matter which is absolutely unfusible in the fires of our furnaces. We may easily perceive, that if such a mixture be exposed to a heat sufficient to melt entirely the vitrifiable ingredient, that this matter will actually melt; but as it is intermixed with another matter which does not melt, and which consequently preserves its consistency and opacity, the whole must form a compound partly opake and partly transparent; or rather a semi-transparent mass; that is, a semi-vitrified substance, or porcelain, but of a kind very different from the former; for as the fusible part of this latter has produced all its effect, and as it has been as much fused as it can be during the baking of the porcelain, the compound may be exposed a second time to a more violent fire without approaching nearer to a compleat vitrification, or without departing from its state of porcelain. But as oriental porcelain has precisely these appearances and properties, Mr. Reaumur concludes with reason, that it is composed upon this principle; and he afterwards confirmed his opinion by undeniable facts.

Father *Entrecolles*, missionary at China, had sent from thence a summary description of the process by which the inhabitants of that country make their porcelain; and also a small quantity of the materials which they employ in its composition. He said that the Chinese composed their porcelain of two ingredients, one of which is a hard stone or rock, called by them *petuntse*, which they carefully grind to a very fine powder; and the other, called by them *kaolin*, is a white, earthy substance, which they mix intimately with the ground petuntse. Mr. Reaumur examined both these matters, and having exposed them separately to a violent fire, he discovered that the petuntse had fused without addition, and that the kaolin had given no sign of fusibility. He

afterwards

afterwards mixed these matters, and formed cakes of them, which by baking were converted into porcelain similar to that of China. Mr. Reaumur easily found that the petuntse of the Chinese was a hard stone of the kind called vitrifiable, but infinitely more fusible than any of these which were known in Europe; and that the kaolin was a talky matter, reduced to very fine powder (*m*). From that time he hoped to make a porcelain of the same kind as the Chinese with materials found in France. Whether he could not find any materials equal to those of China, particularly that material analogous to the petuntse of the Chinese, or because other occupations prevented the continuance of his researches, we do not know; but we find, from his second Memoir upon porcelain, that he afterwards attempted to make an artificial petuntse, by mixing our vitrifiable stones with salts capable of rendering them fusible, or even by substituting for it glass ready formed, and by adding to these such substances as he thought might be substituted for kaolin. But he probably found he could not execute these intentions, for he did not resume this subject from the year 1729 to 1739,

(*m*) The *petuntse* is improperly ranked amongst the class of earths called vitrifiable, because it is fusible without addition, and because it is not hard enough to elicit sparks from steel; whereas the vitrifiable or siliceous earths are unfusible by fire, unless they contain some metallic mixture, and are very hard. Authors have not described very distinctly the petuntse; some believing it to be an alkaline spar, and others the rhomboidal quartz, called *feldtspar*. But from the later accounts, and from a knowledge of some experiments that have been made successfully concerning porcelain, I believe that the petuntse is different from both these substances, and that it is a white opake fluor. At least I have seen excellent porcelain made with such a fluor together with a white argillaceous earth. The texture of this fluor was laminated, its figure was indeterminate, it was rendered luminous in the dark by friction, it was fusible by violent heat, it was not sufficiently hard to elicit sparks from steel, and it was indissoluble by acids. It seems to be of the same kind as the Bolognian stone, and the white heavy fluors, which, as Mr. Margraaf found, are capable of acquiring by calcination with inflammable matter the property of absorbing light. *See* PHOSPHORIC STONES. Mr. Scheffer's examination of Chinese petuntse, published in the Swed. Trans. 1753, corresponds with the above account, excepting that his specimen appears to have had a greater transparency than the fluor above described, and to resemble the lapis specularis, which also possesses the phosphoric property of the Bolognian stone, and contains, according to Mr. Margraaf's experiments, nearly the same principles as that stone and the heavy white fluors above described. *See* PHOSPHORIC STONES. I do not, however, mean to affirm that no porcelain can be made without such a fluor. I am inclined to believe that porcelains may be made of other materials besides a clay or kaolin, and a white fluor or petuntse. One of the ingredients of the Saxon porcelain is a beautiful white stone, which is not fusible by a most violent heat. See Mr. D'Arcet's Memoir sur l'Action d'un Feu Violent, &c. Mem. de l'Acad. des Sc. 1766. Pure clays singly, or mixed with finely-ground siliceous earth, acquire by violent heat the hardness and all the properties, excepting the semi-transparency, of porcelain.

The *kaolin* of the Chinese is a white argillaceous earth, sometimes intermixed with particles of mica, and, as Mr. Bomare affirms, sometimes with particles of quartz and of calcareous earth. But the quantity of the last substance must be very small, as it would render the argillaceous earth fusible, and consequently unfit for the purpose of a kaolin. Mr. Guettard, who has written a Memoir upon the ingredients of Porcelain (Mem. of the Acad. of Sciences, 1765) describes the kaolin as a white argillaceous earth without any calcareous mixture. Probably the calcareous particles found in the specimen analised by Mr. Bomare, and perhaps also the particles of quartz and of mica, are not necessary and constant parts of kaolin.

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when he gave a proceſs for converting common glaſs to a ſingular kind of porcelain, to which he has given his name, and of which we ſhall treat in the following article.

Although Mr. Reaumur has not exhauſted entirely this ſubject, he has ſurmounted many difficulties, and has given juſt notions concerning it: In a word, he has opened the road for all thoſe who afterwards engaged in this purſuit, and has therefore a right to ſhare the honor of the important diſcoveries which have been ſince made by others.

But as a perſon who firſt unravels ſo intricate and hidden a matter as the manufacture of porcelain, can ſcarcely diſcover every thing concerning his ſubject, ſo Mr. Reaumur has been miſtaken, or rather miſled in two important points. His firſt error concerns the Saxon porcelain, which he confounds with the other fuſible porcelains made in Europe. I do not know whether formerly a porcelain was made in Saxony, compoſed entirely of fuſible or vitrifiable materials, the vitrification of which was ſtopt in proper time. Poſſibly this was the firſt kind of porcelain made in that country, and which Mr. Reaumur had examined. But I am certain that I have never ſeen any ſuch Saxon porcelain, and that all of that country which I have examined was capable of reſiſting the moſt violent fires without fuſion, as well, at leaſt, as thoſe of China and Japan. Mr. Reaumur might have been miſled by the appearance of the internal texture of this porcelain. For when a piece of it is broken, its internal ſurface does not appear granulous, but compact, uniform, ſmooth, ſhining, and much reſembling white enamel. But this appearance, ſo far from ſhewing that Saxon porcelain is a fuſed or vitrified ſubſtance, proves that it is not entirely compoſed of fuſible matters. All who have conſidered attentively this ſubject know that the internal ſurface of the moſt fuſible porcelains is alſo the leaſt denſe and leaſt compact: the reaſon of which is, that no vitreous matter can be ſmooth and denſe internally, unleſs it has been completely fuſed. But if the denſity and ſhining appearance of the internal ſurface of the Saxon porcelain were only the effects of the fuſion of a vitreous matter, how could we conceive that veſſels formed of that matter ſhould have ſuſtained the neceſſary fuſion for giving this denſity and ſhining appearance, without having entirely loſt their ſhape? The impoſſibility of this is evident to any perſons who have been converſant in theſe matters, and in the fuſion of glaſs.

This quality of the Saxon porcelain muſt therefore proceed from another cauſe. It does indeed contain, as every porcelain does, particularly thoſe of China and Japan, a fuſible ſubſtance, which has been even completely fuſed during the baking. Its denſity alſo and its internal luſtre proceed chiefly from this fuſed matter; but we are alſo certain that it contains a large quantity of a ſubſtance abſolutely unfuſible, from which it receives its admirable whiteneſs, its firmneſs and ſolidity, during the baking; in a word, which ſupplies the place of the oriental kaolin, and which has the property of contracting its dimenſions conſiderably while it incorporates with the fuſible ſubſtance. If it be ſubjected to the moſt deciſive trial, namely, the action of a violent fire, capable of melting every porcelain compoſed of fuſible matters alone, I affirm, after many experiments, that it cannot be fuſed, unleſs by a fire capable alſo of melting the beſt Japaneſe porcelain. The Saxon porcelain is therefore not to be confounded with thoſe which are vitreous and fuſible, but is in its kind

as excellent as that of Japan, and perhaps ſuperior, as we ſhall ſee when we enumerate the qualities which conſtitute the excellence of porcelain. The ſubject of Mr Reaumur's ſecond error, or, at leaſt, that which he has not ſufficiently explained, is the *kaolin* of China. According to him, this matter is a fine talky powder, from the mixture of which with petuntſe, the oriental porcelain is formed. Poſſibly a very finely-ground talky ſubſtance mixed with petuntſe might form a porcelain ſimilar to the oriental; but perſons acquainted with the manufacture of any porcelain, muſt perceive the impoſſibility of forming veſſels, unleſs the paſte of which they are made be ſo ductile and tenacious, that it may be worked upon a potter's lathe, or at leaſt that it may be moulded. But talks or any kinds of ſtones, however finely ground, cannot acquire the requiſite tenacity, which clays only, of all known earthy ſubſtances, poſſeſs. The Chineſe porcelain veſſels evidently appear to be turned upon the lathe, ſince they retain the marks of it; hence they muſt have been formed of a very tenacious paſte, and conſequently the kaolin is not a purely talky matter, but is mixed with clay; or elſe the petuntſe and kaolin are not, as Mr. Reaumur ſuppoſes, the only ingredients of the paſte of which Chineſe porcelain is formed, but a ſufficient quantity of ſome binding matter, unknown to father d'Entrecolles and Mr. Reaumur, muſt be alſo added.

Although, ſince Mr. Reaumur, no ſcientific perſon has written concerning porcelain, many have attempted to make it. Manufactures have been eſtabliſhed in almoſt all the ſtates of Europe. Beſides that of Saxony, which has been long eſtabliſhed, porcelain is alſo made at Vienna, at Frankendal, and lately in the neighbourhood of Berlin. All theſe German porcelains are ſimilar to the Saxon, and are made of materials of the ſame kind, although they differ ſomewhat from each other. England and Italy alſo have their porcelains, the chief of which are thoſe of Chelſea and of Naples. Mr. de la Condamine, in his laſt journey into Italy, viſited a manufacture of porcelain eſtabliſhed at Florence by the Marquis de Ginori, then governor of Leghorn. Mr. de la Condamine obſerved particularly the large ſize of ſome pieces of this porcelain. He ſays he ſaw ſtatues and groupes half as large as nature, modelled from ſome of the fineſt antiques. The furnaces in which the porcelain was baked were conſtructed with much art, and lined with bricks made of the porcelain materials. The paſte of this porcelain is very beautiful; and from the grain of broken pieces of it, it appears to have all the qualities of the beſt Chineſe porcelain. A whiter glazing would be deſirable, which they might probably attain, if the Marquis Ginori was not determined to uſe thoſe materials only which were found in that country.

But in no ſtate of Europe have ſuch attempts been made to diſcover porcelain, or ſo many manufactures of it been eſtabliſhed, as in France. Before even Mr. Reaumur had publiſhed on this ſubject, porcelain was made at Saint Cloud, and in the ſuburb of St. Antoine at Paris, which was of the vitreous and fuſible kind, but conſiderably beautiful. Since that time, conſiderable manufactures of it have been eſtabliſhed at Chantilly, at Villeroi, and at Orleans; the porcelains of which have a diſtinguiſhed merit. But certainly the admirable works produced in the King's manufacture at Sèvres does moſt honor to France. This porcelain holds at preſent the firſt rank, from its ſhining white, its beautiful glazing, and colored grounds, in which no porcelain has

ever equalled it. The magnificence of the gilding, the regularity and elegance of its forms, surpass every thing of the kind. In the painting and sculpture much genius and talents are displayed. We cannot commend this work more, than by mentioning that Messrs. Bachelier and Falconet preside and direct it. Lastly, as all the operations of this truly great and royal establishment are directed by men of known capacity, assisted by philosophical and chemical researches, this manufacture is upon the point of producing porcelain capable of emulating or equalling the most perfect and most solid works of this kind (*n*). We ought also to give due praises to several of our contemporaries and countrymen, who have distinguished themselves in their attempts in this way. Mr. Guettard, physician of the Faculty at Paris, an able naturalist of the Academy of Sciences, and who has particularly applied himself to the study of earths and fossils, seems to have been one of the first who, since Mr. Reaumur, pretended to have found in France a kaolin and petunse of the same nature as the Chinese.

Mr. Guettard has lately published an account of his discoveries on this subject, in the Memoirs of the Academy of Sciences for the year 1765. The kaolin which he employed was a white argillaceous earth, filled with mica, which he found in the neighbourhood of Alençon; and his petunse is a hard, quartzose grit stone (*o*), found abundantly in the same country, with which the streets of Alençon are paved. We also know that Mr. Guettard had begun to make his experiments on porcelain with these materials in the year 1751, together with the late Duke of Orleans, to whom he was attached. The Count de Lauraguais, of the Academy of Sciences, who has acquired a distinguished reputation in chemistry by several excellent discoveries, on the acetous ether, on the solution of sulphur by spirit of wine, on the inflammation and crystallization of radical vinegar, &c. engaged in the pursuit of porcelain for several years with uncommon ardor and constancy. He spared no trouble nor expence to attain his purpose, which was to make porcelain equal in all respects to that of China and Japan. He shewed some pieces made by him, in the year 1766, to the Members of the Academy of Sciences. The persons appointed by them to examine it gave their opinion, that of all the porcelains made in this country, that of the Count de Lauraguais most resembled the

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as excellent as that of Japan, and perhaps superior, as we shall see when we enumerate the qualities which constitute the excellence of porcelain. The subject of Mr Reaumur's second error, or, at least, that which he has not sufficiently explained, is the *kaolin* of China. According to him, this matter is a fine talky powder, from the mixture of which with petuntse, the oriental porcelain is formed. Possibly a very finely-ground talky substance mixed with petuntse might form a porcelain similar to the oriental; but persons acquainted with the manufacture of any porcelain, must perceive the impossibility of forming vessels, unless the paste of which they are made be so ductile and tenacious, that it may be worked upon a potter's lathe, or at least that it may be moulded. But talks or any kinds of stones, however finely ground, cannot acquire the requisite tenacity, which clays only, of all known earthy substances, possess. The Chinese porcelain vessels evidently appear to be turned upon the lathe, since they retain the marks of it; hence they must have been formed of a very tenacious paste, and consequently the kaolin is not a purely talky matter, but is mixed with clay; or else the petuntse and kaolin are not, as Mr. Reaumur supposes, the only ingredients of the paste of which Chinese porcelain is formed, but a sufficient quantity of some binding matter, unknown to father d'Entrecolles and Mr. Reaumur, must be also added.

Although, since Mr. Reaumur, no scientific person has written concerning porcelain, many have attempted to make it. Manufactures have been established in almost all the states of Europe. Besides that of Saxony, which has been long established, porcelain is also made at Vienna, at Frankendal, and lately in the neighbourhood of Berlin. All these German porcelains are similar to the Saxon, and are made of materials of the same kind, although they differ somewhat from each other. England and Italy also have their porcelains, the chief of which are those of Chelsea and of Naples. Mr. de la Condamine, in his last journey into Italy, visited a manufacture of porcelain established at Florence by the Marquis de Ginori, then governor of Leghorn. Mr. de la Condamine observed particularly the large size of some pieces of this porcelain. He says he saw statues and groupes half as large as nature, modelled from some of the finest antiques. The furnaces in which the porcelain was baked were constructed with much art, and lined with bricks made of the porcelain materials. The paste of this porcelain is very beautiful; and from the grain of broken pieces of it, it appears to have all the qualities of the best Chinese porcelain. A whiter glazing would be desirable, which they might probably attain, if the Marquis Ginori was not determined to use those materials only which were found in that country.

But in no state of Europe have such attempts been made to discover porcelain, or so many manufactures of it been established, as in France. Before even Mr. Reaumur had published on this subject, porcelain was made at Saint Cloud, and in the suburb of St. Antoine at Paris, which was of the vitreous and fusible kind, but considerably beautiful. Since that time, considerable manufactures of it have been established at Chantilly, at Villeroi, and at Orleans; the porcelains of which have a distinguished merit. But certainly the admirable works produced in the King's manufacture at Sèvres does most honor to France. This porcelain holds at present the first rank, from its shining white, its beautiful glazing, and colored grounds, in which no porcelain has ever

ever equalled it. The magnificence of the gilding, the regularity and elegance of its forms, surpass every thing of the kind. In the painting and sculpture much genius and talents are displayed. We cannot commend this work more, than by mentioning that Messrs. Bachelier and Falconet preside and direct it. Lastly, as all the operations of this truly great and royal establishment are directed by men of known capacity, assisted by philosophical and chemical researches, this manufacture is upon the point of producing porcelain capable of emulating or equalling the most perfect and most solid works of this kind (*n*). We ought also to give due praises to several of our contemporaries and countrymen, who have distinguished themselves in their attempts in this way. Mr. Guettard, physician of the Faculty at Paris, an able naturalist of the Academy of Sciences, and who has particularly applied himself to the study of earths and fossils, seems to have been one of the first who, since Mr. Reaumur, pretended to have found in France a kaolin and petuntse of the same nature as the Chinese.

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porcelain of China and Japan in ſolidity, grain, and unfuſibility. It were to be wiſhed that it poſſeſſed equally the other qualities eſſential to the excellence of porcelain, namely, the whiteneſs and luſtre obſervable in the ancient Japaneſe porcelain (*p*).

We ſhall not here particularly examine the qualities of the ſeveral porcelains now known. We ſhall only ſhew what thoſe qualities are which conſtitute the perfection of porcelain. We muſt firſt carefully diſtinguiſh the qualities which only contribute to beauty and external appearance, from the intrinſic and eſſential properties in which the goodneſs and ſolidity of porcelain conſiſt. All perſons who have made experiments in this way have ſoon diſcovered the poſſibility of making compounds very white, beautifully ſemi-tranſparent, and covered with a ſhining glazing, but which cannot be worked for want of tenacity, are not ſufficiently compact, are eſſentially fuſible, are ſubject to break by ſudden application of heat and cold; and, laſtly, the glazing of which cracks, becomes rough, and conſequently loſes its luſtre by uſe, becauſe it is too ſoft.

On the other ſide, we ſhall alſo find it not difficult to compoſe very tenacious paſtes, which ſhall be capable of being eaſily worked and well baked, which in the baking ſhall acquire the deſirable hardneſs and denſity, which are unfuſible, and capable of ſuſtaining very well the ſudden change of heat and cold; and, in a word, which ſhall have all the qualities of the moſt excellent porcelain, excepting whiteneſs and beauty. We ſhall ſoon ſee that the materials fit for the compoſition of ſuch porcelains may be found abundantly in every country. The only difficulty then in this inquiry concerning porcelain is, to unite beauty and goodneſs in one compoſition. I acknowledge that nature ſeems to be very ſparing of materials fit for this purpoſe, and therefore perfect porcelain will always be a dear and valuable commodity.

Many will be ſurprized when I affirm, that before we had any knowledge of oriental porcelain, and from time immemorial, porcelain was made here equal in goodneſs and in eſſential qualities, and was univerſally uſed and even ſold very cheap. For thoſe potteries which we call *grais* or *ſtone-ware* are not of modern invention, and have all the eſſential qualities of the beſt Japaneſe. For if we except whiteneſs, on which alone the ſemi-tranſparency depends, and compare all the properties of Japaneſe porcelain with thoſe of our ſtone-ware, no difference can be found betwixt them. The ſame grain appears internally in both; the ſame ſound is produced by ſtriking them when properly ſuſpended; the ſame denſity; the ſame hardneſs, by which they ſtrike fire with ſteel; the ſame faculty of ſuſtaining the heat of boiling liquors without breaking, and the ſame unfuſibility in fire, are obſervable. Laſtly, if the earths of which ſtone-ware is made were free from heterogeneous coloring matters, which prevent their whiteneſs and ſemi-tranſparency; if veſſels were carefully formed; if all the proper attentions were given; and if theſe veſſels were cover-

(*p*) The porcelain made by that ingenious and ſcientific nobleman is ſaid to have poſſeſſed the intrinſic excellencies of porcelain, as eminently, at leaſt, as even the Saxon or oriental. A gentleman of undoubted veracity has aſſured me, that when the Count de Lauraguais was a few years ago in England, he ſaw him heat a piece of his porcelain till it was red-hot, and then throw it into cold water, without breaking or cracking it.

ed over with a fine glazing; they would be as perfect porcelain as that of Japan. The most perfect porcelain, therefore, is nothing else than a fine white stone-ware. (q)

Earths of this kind are probably more rare in Europe than in Japan and China. And probably also the want of these earths was the cause that the first makers of porcelain in this country confined themselves to an external imitation, by employing nothing but vitrifiable matters with fusible salts and a small quantity of white earth, from which fusible and vitreous porcelains were composed, which might be called *false porcelains*. But things are much changed since these first attempts Besides the discoveries of the Count de Lauraguais and of Mr. Guettard, genuine white porcelains have been made a long time ago in Germany, especially in Saxony and at Frankendal. The new porcelain, a trial of which is just finished at the King's manufacture, is of this kind. (r)

These porcelains are not inferior in any respect to the oriental; they are even much superior in beauty and whiteness to the modern oriental porcelain, which has much degenerated in these respects; they seem even to excel the oriental in the most valuable quality of porcelain, namely, the property of sustaining the sudden change of heat and cold. We cannot judge of the quality of porcelain by a slight trial: for so many circumstances concur to make a piece of porcelain capable or incapable of sustaining the sudden application of heat and of cold, that if at the same time boiling water be poured into two vessels, one of which is good porcelain and the other bad, the former may possibly break, and the latter remain entire: the only true method of discovering good porcelain in this respect is, to examine several pieces of it which are daily used, for instance, a set of coffee-cups. But I have observed that in many such pieces of oriental porcelain, which have been long and daily used, cracks in the direction of their height may be always perceived, which are never seen in the good European porcelains.

Every one talks of porcelain, and yet few are connoisseurs of it. None can be considered as such but those who have long made it an object of their inquiries. That the ancient Japanese porcelain is the most perfect, is a general opinion. This porcelain is indeed very beautiful, and we must also acknowledge that its quality is excellent. It has been our model, and has long been the object of our admiration and emulation; but which we have been never able to equal, and which many persons believe never can be equalled. Some persons even decry the Saxon porcelain for a quality which really gives it a superiority to the Japanese, namely, the greater smoothness, lustre, and less granulous appearance of its internal surface than the oriental. The resemblance of this

(q) The French stone ware, or *potterie de grais*, is formed of a whitish clay, in which a good deal of fine white sandy particles are intermixed. The English *stone-ware* is composed of tobacco-pipe clay and ground flints. This ware, when sufficiently burnt, has, as well as the French, the qualities of porcelain which the author calls essential, namely, strength, hardness, the property of sustaining the heat of boiling water, and unfusibility. *See* POTTERY.

(r) I have nevertheless seen several pieces of the porcelain of Sevres, lately brought from thence, which were not of the kind called by the author *genuine*, but which had the properties and defects mentioned in the above note (n).

surface

furface to that of glafs has evidently fuggefted this notion; and it would be well founded, if the denfity and luftre of this porcelain proceeded only from a fufible and vitreous quality; but as they do not, and as this porcelain is as fixed and as unfufible as the Japanefe, its denfity, fo far from being a fault, is a valuable quality. For we muft allow, that of porcelains equal in other refpects, thofe are beft which are moft firm and compact. Hence, the interior fubftance of the Japanefe porcelain is efteemed for its greater denfity, compactnefs and luftre, than our vitreous or fritt porcelains, becaufe thefe qualities indicate greater cohefion, and more intimate incorporation of its parts. For the fame reafon alfo the fuperior denfity of the Saxon porcelain ought to give it the preference to the Japanefe. Befides, nothing would be eafier than to give the Saxon porcelain the granulous texture of the Japanefe, by mixing with the pafte a certain quantity of fand. But the perfons who perfected that manufacture were certainly fenfible, that fuch a conformity to the Japanefe porcelain would leffen the merit of theirs. For we know, that in general porcelains are better in proportion as they contain a larger proportion of clay or earth, and lefs of fand, flints, or other matters of that kind.

What we have faid concerning porcelain in general, and the principal kinds of it, feems fufficient to give juft notions of it, if not to perfons who without confidering the fubject are determined to prefer the moft ancient, to thofe, at leaft, who have made experiments on this fubject, or who, having a fufficient knowledge of chemiftry, are capable of ftudying and examining it thoroughly. We fhall finifh this article by giving a fhort defcription of the method of manufacturing porcelain.

The bafis of the porcelains which we have called fufible, vitreous, or falfe porcelains, is called by artifts a *fritt*; which is nothing elfe than a mixture of fand or of powdered flints, with falts capable of difpofing them to fufion, and of giving them a great whitenefs by means of a fufficient heat. This fritt is to be then mixed with as much, and no more, of a white tenacious earth, of an argillaceous or marly nature, than is fufficient to make it capable of being worked upon the wheel. The whole mixture is to be well ground together in a mill, and made into a pafte, which is to be formed, either upon the wheel or in moulds, into pieces of fuch forms as are required.

Each of thefe pieces when dry is to be put into a cafe made of earthen ware (*s*); which cafes are to be ranged in piles one upon another, in a furnace or kiln, which is to be filled with thefe to the roof. The furnaces are chambers or cavities of various forms and fizes, and are fo difpofed that their fire-place is placed on the outfide oppofite to one or more openings, which communicate within the furnace. The flame of the fuel is drawn within the furnace, the air of which rarefying, determines a current of air from without inwards, as in all furnaces. At firft a very little fire is made, that the furnace may be heated gradually, and is to be encreafed more and more, till the porcelain is baked,

(*s*) The cafes are called by Englifh potters, *feggars* They are generally formed of coarfer clays, but which muft be alfo capable of fuftaining the heat required without fufion. By means of thefe cafes, the contained porcelain is preferved from the fmoke of the burning fuel. The whitenefs of the porcelain depends much on their compactnefs of texture by which the fmoke is excluded, and on the purity of the clay of which they are made.

that

that is, till it has acquired its proper hardneſs and tranſparency; which is known by taking out of the furnace from time to time, and examining, ſmall pieces of porcelain, placed for that purpoſe in caſes which have lateral openings. When theſe pieces ſhew that the porcelain is ſufficiently baked, the fire is no longer to be ſupplied with fuel, the furnace is to be cooled, and the porcelain taken out, which in this ſtate reſembles white marble not having a ſhining ſurface, which is afterwards to be given by covering them with a vitreous compoſition, called the *glazing*.

The porcelain when baked and not glazed is called *biſcuit*, which is more or leſs beautiful according to the nature of the porcelain. The manufacture of Sévres excells all others in this reſpect, and it is therefore the only one which can produce very fine pieces of ſculpture; that is, in which all the fineneſs of the workmanſhip is preſerved, and which are preferable in ſmoothneſs and whiteneſs to the fineſt marble of Italy.

If this porcelain had no other merit, it would be ſufficient to induce true connoiſſeurs to prefer it to any other matter, however ſolid, without this advantage.

As no piece of ſculpture of this kind can preſerve all the delicacy of its workmanſhip when covered with a glazing; and as ſculptors avoid poliſhing their marble figures, becauſe the luſtre of the poliſh is diſadvantageous; therefore in the manufacture of Sévres, all figures, or little ſtatues, and even ſome ornamental vaſes, are left in ſtate of biſcuit. The other pieces of porcelain are to be glazed in the following manner.

A glaſs is firſt to be compoſed ſuited to the nature of the porcelain to which it is to be applied, for every glaſs is not fit for this purpoſe. We frequently find that a glaſs which makes a fine glazing for one porcelain ſhall make a very bad glazing for another porcelain, ſhall crack in many places, ſhall have no luſtre, or ſhall contain bubbles. The glazing then muſt be appropriated to each porcelain, that is, to the hardneſs and denſity of the ware, and to the ingredients of its compoſition, &c.

Theſe glazings are prepared by previouſly fuſing together all the ſubſtances of which they conſiſt, ſo as to form vitreous maſſes. Theſe maſſes are to be ground very finely in a mill. This vitreous powder is to be mixed with a ſufficient quantity of water, or other proper liquor, ſo that the mixture ſhall have the conſiſtence of cream of milk. The pieces of porcelain are to be covered with a thin ſtratum of this matter, and when very dry they are to be again put into the furnace, in the ſame manner as before, for the forming of the biſcuit, and to be continued there till the glazing be well fuſed. The neceſſary degree of fire for fuſing the glazing is much leſs than that for baking the paſte.

The pieces of porcelain which are intended to remain white are now finiſhed; but thoſe which are to be painted and gilded muſt undergo further operations. The colors to be applied are the ſame as thoſe uſed for enamel painting. They all conſiſt of metallic calxes bruiſed and incorporated with a very fuſible glaſs. Crocus of iron furniſhes a red color; Caſſius's precipitate of gold makes the purple and violet; copper calcined by acids and precipitated by an alkali gives a fine green; zaffre makes the blue; earths ſlightly ferruginous produce a yellow; and, laſtly, brown and black colors are produced by calcined iron,

together with a deep blue of zaffre. These colors being ground with gum-water, or with oil of spike, are to be employed for the painting of the porcelain with designs of flowers and other figures *(t)*. For gilding, a powder or calx of gold is to be applied in the same manner as the colored enamels *(u)*. The painted and gilded porcelains are to be then exposed to a fire capable of fusing the glass, with which the metallic colors are mixed. Thus the colors are made to adhere, and at the same time acquire a gloss equal to that of the glazing. The gold alone has not then a shining appearance, which must be afterwards given to it by burnishing with a blood-stone.

The operations for the unfusible porcelains, and also for such as are of the nature of stone-ware, are somewhat more simple. The sands and stones which enter into their composition are to be ground in a mill: the earths or clays are to be washed: the materials are to be well mixed and formed into a paste: the pieces are first rudely formed upon a potter's wheel; and when dry or half dry, they are turned again upon the wheel, and their form is made more perfect: they are then placed in the furnace, not to bake them, but only to apply a sufficient heat to give them such a solidity that they may be handled without breaking, and may receive the glazing. As the pieces of porcelain after this slight heat are very dry, they imbibe water readily. This disposition assists the application of the glazing. The vitrifiable or vitrified matter of this glazing, which has been previously ground in a mill, is to be mixed with such a quantity of water, that the liquor shall have the consistence of milk. The pieces of porcelain are hastily dipt in this liquor, the water of which they imbibe, and thus on their surface is left an uniform covering of the glazing materials. This covering, which ought to be very thin, will very soon become so dry, that it cannot stick to the fingers when the pieces are handled.

The pieces of this porcelain are then put into the furnace to be perfectly baked. The heat is to be raised to such a height, that all within the furnace shall be white, and the cases shall be undistinguishable from the flame. When, by taking out small pieces, the porcelain is known to be sufficiently baked, the fire is discontinued, and the furnace cooled. If the baking has been well performed, the pieces of porcelain will be found by this single operation to be rendered compact, sonorous, close-grained, moderately glossy, and covered externally with a fine glazing. The painting and gilding of this porcelain are to be executed in a manner similar to that already described. *(x)*

(t) See the article ENAMEL, *and the* Note *subjoined.*

(u) The several powders of gold employed for this purpose are described in a note subjoined to the article GILDING.

(x) I purposely avoid giving any opinion concerning the relative advantages and defects of the porcelains of British manufacture. I shall only add, that we have reason to believe, that the materials of genuine porcelain might be discovered in this island, if search were made by intelligent persons. The steatites or soap-rock of Cornwall is probably a good *kaolin*; and I have sometimes found stones in England in which the white opake fluor above described was blended with a pure quartz, and which I am well convinced might be successfully employed as a *petuntse*. With pleasure I hear that an ingenious gentleman has found a true kaolin and petuntse in Devonshire and Cornwall, and that he has lately established a manufactory of genuine porcelain. It is to be hoped that he may succeed in the introduction of this very elegant and useful manufactory: and

DXLVIII. PORCELAIN *of* MR. REAUMUR. Mr. Reaumur having made many experiments to discover the nature of the materials which enter into the composition of the oriental porcelain, and having ascertained that all porcelain is an intermediate substance betwixt an earth and glass, very ingeniously thought of reducing glass ready made to the state of porcelain, by undoing the vitrification, or partly unvitrifying it: hence this kind of ware has been called *porcelain unvitrified.* Mr. Reaumur gave the quality of porcelain to glass; that is, he rendered glass of a milky color, semi-transparent, so hard as to strike fire with steel, unfusible, and of a fibrous grain, by means of cementation. The process which he published is not difficult. Common glass, such as that of which wine-bottles are made, succeeds best. The glass-vessel which is to be converted into porcelain is to be enclosed in a baked earthen case or segger. The vessel and case are to be filled with a cement composed of equal parts of sand and powdered gypsum or plaster; and the whole is to be put into a potter's kiln, and to remain there during the baking of common earthen ware; after which the glass vessel will be found transformed into such a matter as we have described.

This kind of porcelain has not a very white color, particularly on its surface; but for some purposes it may be useful, especially for chemical vessels. Mr. Reaumur has not explained how this transformation is effected. The cause of it probably is, that the vitriolic acid of the gypsum quits its basis of calcareous earth, and unites with the alkaline salt and saline earth of the glass, with which it forms a kind of salt or selenites different from the calcareous selenites, by the interposition of which matter the glass acquires the qualities of porcelain. (y)

and although many and great difficulties, besides the discovery of proper materials, must occur in the execution of that work, yet these are not insuperable.

(y) Mr Reaumur says, that glass thus rendered opake, white, unfusible, and hard, is inferior in beauty to the oriental porcelain; but that in utility and every essential quality of porcelain it is equal to any, and even superior in the property of sustaining alterations of heat and cold.

The character given by Mr. Reaumur of this porcelain induced Dr. Lewis (who had also observed the changes produced upon glass-retorts exposed to violent heat in a sand-bath) to make further experiments on this matter, an account of which he has published in the *Philosophical Commerce of Arts*, a work which we much wish to see prosecuted in the same able and useful manner in which it has been begun.

From Dr. Lewis's experiments we find the following results. 1. Green glass cemented with white sand received no change in a heat below ignition. In a low red-heat the change proceeded exceeding slowly; and in a *strong red-heat*, approaching to whiteness, the thickest pieces of glass bottles were thoroughly converted in the space of three hours. 2. The glass suffered the following *progression of changes* by continued heat: First, its surface became blue, its transparency was diminished, and a yellowish hue was observable when it was held between the eye and the light. Afterwards it was changed a little way on both sides into a white substance, externally still bluish; and as this change advanced still further and further within the glass, the color of the vitreous part in the middle approached nearer to yellow: the white coat was of a fine fibrous texture, and the fibres were disposed nearly parallel to one another, and transverse to the thickness of the piece: by degrees the glass became throughout white and fibrous, the external bluishness at the same time going off, and being succeeded by a dull whitish or dun color: by a still longer continuance in the fire the fibres were changed gradually from the external to the internal part, and con-

DXLIX. PORPHYRY. (z)

DL. POTASH. *See* Alkali (Fixed).

DLI. POTTERY. The art of making pottery is intimately connected with chemiſtry, not only from the great uſe made of earthen veſſels by

verted into grains; and the texture then was not unlike that of common porcelain. The grains, at firſt fine and ſomewhat gloſſy, appeared afterwards larger and duller, and at length the ſubſtance of the glaſs became porous and friable, like a maſs of white ſand ſlightly cohering. 3. Concerning the *qualities* of the converted glaſs Dr. Lewis obſerves, that the whiteneſs of the internal part was not inferior to that of porcelain, but that its ſurface was the leaſt beautiful, that the thick pieces were quite opake, and that ſeveral thin pieces were ſemi-tranſparent: that while it remained in a fibrous ſtate, its hardneſs became greater than that of glaſs, or of the common kinds of porcelain; it was capable of ſuſtaining ſudden changes of heat and cold better than any porcelain; and in a moderate white heat, it was fuſible into a ſubſtance not fibrous, but vitreous and ſmooth, like white enamel: that when its texture had become coarſely granulated, it was now much ſofter and unfuſible: and, laſtly, that when ſome coarſely granulated, unfuſible pieces which, with the continuance of a moderate heat, would have become porous and friable, were ſuddenly expoſed to an intenſe fire, they were rendered remarkably more compact than before; the ſolidity of ſome of them being ſuperior to that of any other ware. 4. No differences appeared in the internal color, hardneſs, texture, or the regular ſucceſſion of changes, from the uſe of *different cementing ſubſtances*; though in external appearances the differences were conſiderable. All the pieces which had been ſurrounded with charcoal or with ſoot were externally of a deep black color, which did not diſappear by expoſure to a ſtrong fire during an hour, with free acceſs of air. Colored clays and ſands communicated different ſhades of a brown color; and white earths gave whitiſh, greyiſh, or browniſh tinges. White ſand, calcined flints, and gypſum, gave in general the greateſt whiteneſs, and tobacco-pipe clay the greateſt gloſſineſs and brightneſs. 5. Glaſſes compoſed of earths without alkaline ſalt, glaſs of lead, flint-glaſs, crown-glaſs, looking-glaſs plates, a glaſs prepared with calcined flints and a fixed alkaline ſalt, and even green glaſs which had been fuſed together with a ninth part of alkaline ſalt, ſuffered none of the above alterations by cementation. Green bottle-glaſs and common window-glaſs were moſt ſuſceptible of theſe alterations. 6. The changes produced by cementation could not proceed from any abſorption of matter from the cementing ſubſtance; becauſe no increaſe of weight was given, and becauſe the ſame changes were produced upon a piece of glaſs merely by heat, without any cementing ſubſtance. The real *cauſe of theſe changes* ſeems to be, that a part of the alkaline ſalt of the glaſs, to which the vitrified ſtate of the earth is owing, exſudes by heat, and is imbibed by the ſurrounding matters, as appears from the concretion obſervable in theſe matters after a long cementation. Thoſe glaſſes only are ſuſceptible of change which contain but a ſmall quantity of alkaline ſalt; becauſe no more of this ſalt being contained than is neceſſary to give a vitrified ſtate to the earth, any exſudation of it muſt in ſome meaſure unvitrify the glaſs, and approximate it more and more to the ſtate of the earth of which it was formed. Perhaps alſo the firſt degree of change may partly depend on an alteration produced by the heat in the glaſs itſelf conſidered as a compound, or in the nature of its alkaline ingredients, which we know are liable, by expoſure to fire, to loſe ſomething of their ſaline nature, and to be partly changed to earths.

(z) Porphyry is a compound ſtone conſiſting of Jaſper, in which particles of feltſpar, and ſometimes of mica and baſaltes, are interſperſed. Its colors are green, red, black, brown, or dark-grey, varying according to the color of the jaſper which is the baſis of this compound ſtone, and of the quantity and colors of the interſperſed particles. Porphyry is generally fuſible by fire. Its fuſibility is probably owing to the metallic matter with which the jaſper is tinged, and to the baſaltes or other fuſible particles intermixed. The ſurface of this ſtone is generally covered with a whitiſh cruſt.

chemiſts,

chemists, but also because all the processes of this art, and the means of perfecting it, are dependent on chemistry. We must, however, acknowledge, that although chemists have most interest to procure good crucibles and other earthen vessels, this art has been left almost entirely to the potter. Mr. Pott is the first and the only chemist who has attended to this object. Besides many experiments related in his Lithogeognosia, from which much instruction may be received relating to the perfection of chemical vessels, he has written a treatise expresly on this subject, in which he gives many compositions for crucibles, the chief of which shall be mentioned in this article.

All kinds of pottery are in general made of clays or argillaceous earths; because these earths are capable of being kneaded, of easily receiving any form, and of acquiring much solidity and hardness by exposure to fire. But clays differ much in the effects produced upon them by fire. Some clays, which are of the purest kind, resist the most violent fire without receiving any other change than a considerable hardness; but still they are not rendered so hard and compact as other clays. A second kind of clays by exposure to violent heat acquires a hardness equal to that of flints, and a texture compact and glossy, like that of good porcelain; but they are nevertheless unfusible by the most violent heat. These qualities are occasioned by some fusible materials being mixed with them, as sand, chalk, gypsum, or ferruginous earth, which are in too small a quantity to effect a compleat, but only a beginning or partial fusion. Lastly, a third kind of clays is first hardened by fire, and afterwards is compleatly fused. This last kind of clay evidently contains the largest quantity of the fusible matters above-mentioned.

From the properties of these three principal clays we may conclude, that from clays alone three principal kinds of pottery may be produced. With the first kind of clay, pots or crucibles may be formed capable of sustaining the most violent fire without fusion, of containing melted metals, and even hard glasses not too fluid; but which, from want of sufficient compactness, are incapable of containing during a long time in fusion very fusible substances, such as nitre, glass of lead, glasses containing much arsenic, &c. by which substances their pores are pervaded. These clays are employed advantageously for the formation of large pots or crucibles used in glass-houses for containing hard glass, as bottle-glass.

With clays of the second kind may be made crucibles and other potteries, commonly called stone-ware. Potteries made with these earths, when sufficiently baked, are very sonorous, so hard as to strike fire with steel, capable of containing all liquids, of which the former kind, from their porosity, are incapable, and even resist the action of nitre, glass of lead, and other fluxes, when the earth of which they are formed is of good quality: but their hardness and density, which prevents their sudden expansion and contraction, by the hasty application of heat and cold, makes them liable to break in all operations where they are suddenly exposed to heat or to cold, as, for instance, in a furnace through which a strong current of air passes. If this kind of pottery had not this inconvenience, it would be the best and most perfect for the purposes of ordinary life and chemistry. Notwithstanding this inconvenience, this is the only pottery that is applicable in many occasions; and then all possible care must be taken

to prevent its breaking, by a very gradual application of heat and cold, and by protecting it from currents of cold air.

Laſtly, with fuſible clays may be made many kinds of veſſels, which are cheap, as they require little fire to bake them; for all this kind of pottery is but ſlightly baked; hence its texture is coarſe and porous. Some utenſils are made of this pottery without glazing, as foot-ſtoves, &c. But in general they are covered with a glazing, without which water or other liquids would paſs through their pores. Some of this pottery, which is finiſhed with more care, is covered with a white enamel, which makes it very neat and like porcelain. This is called Delf Ware, *which ſee*. Other coarſer potteries of this kind are glazed with glaſs of lead mixed with metallic calxes, or fuſible colored earths, from which they receive various colors. This is the ordinary pottery.

Laſtly, a fine kind of pottery is made of white clays, or of ſuch as whiten in the fire, the ſurface of which is vitrified by throwing into the furnace, when the ware is ſufficiently baked, ſome common ſalt and ſalt-petre. This pottery is called *Engliſh-ware*, becauſe the firſt and beſt was made in England. True, white Engliſh ware is not without merit; it is white, fine, well baked, and has ſome ſmall degree of tranſparency when thin; ſo that it is intermediate betwixt porcelain and common ſtone-ware, and may therefore be called a ſemi-porcelain. (*a*)

Some of theſe potteries can ſuſtain a ſudden application of heat and of cold, ſufficiently well for the uſes of a kitchen, and are therefore called *fire-ware*: but theſe are always the coarſeſt, leaſt baked, and the glazing of which is the ſofteſt. They alſo do not laſt long when much uſed; for it is a chimera to ſuppoſe, as ſome perſons do, that pottery may be made capable of ſuſtaining fire like a metal veſſel. We are certain that the beſt of this kind which are employed for this purpoſe, break as ſoon as they are put upon the fire. They do not break ſo as to ſeparate in pieces, or even to let liquors paſs through them; but many ſmall cracks are formed; which we may be aſſured of by the crackling heard upon their being firſt ſet on the fire, by the many cracks which may be perceived in their glazing, and by their ceaſing to ring when ſtruck, after they have been once heated. Each time that theſe veſſels are ſet

(*a*) I have never ſeen any Engliſh ſtone-ware that had the ſemi-tranſparency and whiteneſs mentioned by the author. As the Engliſh ſtone-ware is compoſed of tobacco-pipe clay and ground flints, both which ſubſtances are perfectly unfuſible, ſingly, or jointly, it cannot poſſeſs any degree of tranſparency. The uſe of the flints is to give ſtrength to the ware, ſo that it ſhall preſerve its form during the baking: whereas veſſels made of clay alone, although unfuſible by fire, and capable of acquiring, by having been expoſed to an intenſe heat, the hardneſs of the beſt porcelain; while they are hot, are ſoft, ſink by their weight, ſo as to loſe the form given to them. This ſtone-ware is glazed in the manner mentioned by the author, but by means of common ſalt only, without any mixture of nitre. This glazing has not the beauty or ſmoothneſs of good vitreous glazings. Another kind of ſtone-ware, called *Queen's ware*, is made in England, and lately much uſed. It is compoſed of the ſame materials as the former, but with a leſs proportion of flints, as it is to be expoſed to a leſs violent heat than the former ware; the vitreous glazing with which it is covered not being capable of ſuſtaining ſuch heat. Its color is leſs white than that of the former, having a yellowiſh tinge; but the ware is preferred on account of the ſmoothneſs of its glazing and neatneſs of its forms.

on the fire, many ſmall imperceptible cracks are formed in them, which by frequent uſe become ſo numerous, that the veſſel may be broken by the leaſt force. Thus all the difference betwixt the potteries which are intended to be uſed on the fire and the good ſtone-ware which is not intended for that purpoſe is, that this latter kind may be broken at once, when heated and cooled careleſsly, whereas the former is broken by degrees. Nevertheleſs, this fire-ware is uſeful, as it can ſerve for a ſhort time.

We ſhall not deſcribe the operation of making pottery, becauſe we have already ſpoken of it under the articles DELF-WARE *and* PORCELAIN, from which the common ware only differs, with regard to its manufacture, in its greater ſimplicity. We ſhall here add ſome obſervations concerning chemical veſſels, as retorts, muffles, and crucibles.

All the operations where great heat is employed require veſſels of baked earth; becauſe theſe alone can ſuſtain at once the action of violent fire and of chemical ſolvents. Veſſels made of good baked clay eminently poſſeſs theſe two qualities, and are the beſt which can be employed in chemiſtry; but as they have the inconvenience of breaking by ſudden application of heat and cold, and as many operations do not require veſſels ſo denſe, mixtures of earth have been uſed, of which crucibles are made, capable of being made ſuddenly red-hot, and ſuddenly cooled without breaking, and ſufficiently denſe to contain metals and other matters in fuſion during a long time. The beſt crucibles of this kind are brought from Heſſe, in Germany. Theſe crucibles are made with a good refractory clay, mixed, according to Mr. Pott, with two parts of ſand, of a middling fineneſs, from which the fineſt part has been ſifted. The mixture of ſand with clay produces two good effects; the firſt, to make the clay leaner, as it is called, and thus to prevent the clay from cracking by the contraction it ſuſtains during its drying; and, ſecondly, to prevent its acquiring too great cloſeneſs and compactneſs of texture by being baked. Thus we obtain crucibles moderately denſe, capable of containing metals and other things in fuſion, and infinitely leſs ſubject to break by heat and cold than thoſe made of pure clay.

The particles of the ſand mixed with clay in this compoſition for crucibles ought to be rather of a moderate ſize than very fine; becauſe, as Mr. Pott remarks, the former renders the crucibles much leſs apt to crack than the latter. In the ſecond place, that chemiſt forbids the uſe of ſand, flints, or other earths of that kind in the compoſition of crucibles intended to contain glaſſes or vitrifying matters a long time in fuſion; becauſe theſe vitreous matters act upon ſand, flints, and all thoſe called vitrifiable earths; by which means theſe crucibles are ſoon penetrated and melted.

This inconvenience is prevented, and all the advantages obtained from a mixture of ſand are procured by ſubſtituting to the ſand a good baked clay in groſs powder. In this manner are made the pots which contain the vitrifiable materials in glaſs-houſe furnaces, ſome of which reſiſt the continued fires employed there during three weeks or a month (*b*). The quantity of burnt clay

(*b*) The pots uſed in glaſs-houſes frequently ſuſtain a conſtant fire during ſeveral months, and ſometimes even a year. They become gradually more and more thin, the glaſs or flux contained probably diſſolving them thus ſlowly.

in the composition for crucibles varies in proportion to the nature of the crude clay, from 1, 2, 2½, or even three parts of the former, to one of the latter. In general, the stronger, more tenacious, and compact the crude clay is, the larger quantity of burnt clay ought to be mixed with it.

The crucibles made in France are composed on the same principles. They are made of clay mixed with broken butter-pots, which are a stone-ware made in Normandy and Piccardy. These crucibles resist admirably well sudden heat and cold, and they would be excellent if the crude clay which enters into their composition was capable of resisting a violent fire: but this clay being mixed with martial and pyritous matters swells in the fire, and begins to melt. Besides, these crucibles owe their good quality of not breaking by sudden application of heat and cold to their little density, which is attended with this inconvenience, that they are penetrable by very fluid matters.

We may, from what has been said, perceive the difficulty, perhaps the impossibility, of making perfect crucibles. Mr. Pott has made so many experiments on this subject, that he seems to have exhausted it. The basis of all his compositions was clay; but this he mixed in different proportions with metallic calxes, calcined bones, calcareous stones, talks, amianthus, asbestus, pounce-stones, tripoli, and many others, from none of which did he obtain a perfect composition, as may be seen from his Dissertation: hence we conclude, that we must have in our laboratories crucibles of different kinds suitable to the several operations; Paris crucibles, when the matters contained are not too fluid, and the fire is not too strong; Hessian crucibles, when similar matters are to be exposed to a violent heat; and crucibles of baked clay for vitrescent matters and penetrating fluxes.

Crucibles may possibly be made better than any hitherto known, and of more extensive use. The essential point is to obtain a very refractory clay free from pyritous matter and ferruginous earth, from which the sand must be washed. This must be mixed with two or three parts of the same clay baked and pounded grossly; and of this mixture or paste crucibles must be formed in moulds, and baked in a very strong fire. As retorts and cucurbits are designed for the distillation of liquors generally very corrosive and penetrating, they ought to be made of stone-ware. *(c)*

(c) To what the Author of the Dictionary has said concerning *crucibles*, I shall add some farther extracts from Mr. Pott's *Dissertation* above-quoted.

1. Crucibles made of fat clays are more apt to crack, when suddenly exposed to heat, than those made of lean or meagre clays. *Meagre clays* are those in which a considerable quantity of sand is mixed with the pure argillaceous earth, and *fat clays* are those which contain but a small proportion of sand. 2. Some crucibles become porous by long exposure to fire, and imbibe part of the contained metals. This inconvenience is prevented by glazing the internal and external surfaces, which may be done by moistening these with oil of tartar, or by strewing upon them when wetted with water, powdered glass of borax. These glazings are not capable of containing glass of lead. 3. Crucibles made of burnt clay *grossly powdered*, together with unburnt clay, were much less liable to crack by heat than crucibles made of the same materials, but in which the burnt clay was *finely powdered*, or, than crucibles made entirely of unburnt clay. 4. If the quantity of unburnt clay be too great, the crucible will be apt to crack in the fire. Crucibles made of ten ounces of unburnt clay, ten ounces of grossly powdered burnt clay, and three drams of calcined vitriol, are capable of retaining melted metals,

but

DLII. P O W D E R. This name is given in general to all dry substances when divided into very small parts. As in many chemical operations the substances employed must be necessarily reduced into very fine powder, different methods have been invented for this purpose according to the nature of the substances to be powdered. *See* DIVISION.

In pharmacy many remedies are in form of powder, and which are called *powders*; but these do not belong to our subject. Some chemical preparations and mixtures are known by the name of powder, as the *powder of Algaroth*, *gun-powder*, *fulminating powder*, of all which we shall treat.

DLIII. P O W D E R *of* A L G A R O T H. This preparation, called also *emetic powder* or *mercurius vitæ*, is a kind of calx of regulus of antimony, separated from the butter of antimony by water alone.

The marine acid, which cannot be united to the regulus of antimony but by particular processes and when it is highly concentrated, as we see from the operation of butter of antimony, is much disposed to separate from it; and accordingly is separated, at least the greatest part of it is separated, by dilution with a sufficient quantity of water. When therefore water is poured upon butter of antimony, the same thing happens as when water is mixed with the saline combination of the vitriolic acid with mercury; that is, the greatest part

but are pervaded by glass of lead. The following composition is as good or better than the preceding. Seven ounces of unburnt clay, fourteen ounces of grossly powdered burnt clay, and one dram of calx of vitriol. These crucibles may be rendered more capable of containing glass of lead, by lining their internal surfaces, before they are baked, with unburnt clay diluted with water. They may be further strengthened by making them thicker than is usually done, or by covering their external surfaces with some unburnt clay, which is called *arming* them. 4. The composition of which crucibles the most capable of containing glass of lead were made, was eighteen parts of grossly powdered burnt clay, as much unburnt clay, and one part of fusible spar. These crucibles must not, however, be exposed too suddenly to a violent heat. 5. Crucibles capable of containing very well glass of lead were made of twenty-four parts of unburnt clay, four parts of burnt clay, and one part of chalk. These required to be armed. 6. Plume-alum powdered, and mixed with whites of eggs and water, being applied to the internal surface of a Hessian crucible, rendered it capable of containing glass of lead during a long time. 7. One part of clay and two parts of Spanish chalk made good crucibles. The substance called Spanish chalk is not a calcareous earth, but appears to be a steatites. 8. Two parts of Spanish chalk and one part of powdered tobacco-pipes made a good composition for lining common crucibles. 9. Eight parts of Spanish chalk, as much burnt clay, and one part of litharge, made solid crucibles. 10. Crucibles made of black-lead are fitter than Hessian crucibles for the melting of metals; but they are so porous, that fused salts pass entirely through them. They are more tenacious than Hessian crucibles, are not so apt to burst in pieces, and are more durable. 11. Crucibles placed with their bottoms upwards are less apt to be cracked during the baking than when placed differently. 12. The paste of which crucibles are made ought not to be too moist, else when dried and baked they will not be sufficiently compact: hence they ought not to be so moist as to be capable of being worked on a potter's lathe, but they must be formed in brass or wooden moulds. *See Mr. Pott's Dissertation on Chemical Vessels.*

Mr. Scheffer says, that the best crucibles cannot easily contain metals dissolved by sulphur, in the operation of parting by means of sulphur. *See* PARTING. He says, that they may be made much more durable and solid, by steeping them a few days in linseed oil, and strewing powdered borax upon them before they are dried. *Mem. Sued.* xiv. 1752.

of

of the regulus of antimony is separated from the marine acid, or at least it retains too little of this acid to continue soluble, but is separated in form of a white precipitate, while the rest of the regulus remains dissolved in water by means of the superabundant acid.

The acid liquor in which the precipitate or powder of algaroth is formed has been called by the ancient chemists, very improperly, the philosophical spirit of vitriol; for it does not contain an atom of vitriolic acid. We must not believe that it is pure marine acid, for it retains, as we have said, a small portion of the regulus of antimony; the proof of which is that this earth may be precipitated and rendered sensible by an alkali.

The earth thus precipitated by water from butter of antimony, after it has been frequently and perfectly washed with much distilled water, is called *powder of Algaroth*, from the name of a physician who used it as a remedy. This preparation of antimony given in doses from a grain to three or four grains is a powerful emetic and purgative; but unconstant in its effects, and even dangerous, as all the preparations of antimony are which are not in a saline state.

Most chemists believe that the powder of algaroth retains a part of the acid of butter of antimony, and attribute its effects partly to this acid. When this powder has not been perfectly washed, it does indeed retain some acid, which may give it a degree of causticity. But we are not certain that all the acid cannot be washed from it by much water, or by being boiled in a large quantity of water. Mr. Beaumé pretends that it is very possible; but however well washed this powder may have been, it still preserves an emetic quality, nearly as great as that of glass of antimony; which is not surprising. For if we suppose that this antimonial earth was absolutely deprived of acid, yet as it was combined with the marine acid, which does not deprive metals of all their phlogiston, it retains enough of this principle to possess an emetic quality, as in general all antimonial calxes do when not perfectly dephlogisticated.

Lemery says, that the powder of algaroth cannot be dissolved either by spirit of nitre or by ordinary aqua regia, but that it is soluble by a mixture of the spirit of nitre, of sea-salt, and of vitriol. As that chemist is very accurate, what he says is probably true. I shall nevertheless observe, that I have dissolved this powder perfectly and entirely with cream of tartar, in the usual manner of dissolving glass of antimony in the preparation of emetic tartar, and thus obtained a neutral crystallizable salt. This experiment induces me to believe, that powder of algaroth may be used advantageously for the preparation of an emetic tartar, of more certain and more uniform quality than that which is prepared from glass of antimony. *See the reasons for this opinion, at the word* TARTAR (EMETIC). *See also the articles* ANTIMONY, BUTTER *of* ANTIMONY, *and* BEZOAR MINERAL.

DLIV. POWDER, (GUN). Gun-powder is an intimate mixture of 75 parts of purified nitre, of $15\frac{1}{2}$ parts of charcoal, and of $9\frac{1}{2}$ parts of sulphur. The quickness of the kindling of this composition, and the violence of the explosion occasioned by this sudden inflammation, is universally known. The theory of the detonation of gun-powder is exactly the same as that of the detonation of nitre with any other inflammable matter. Therefore we refer to the article DETONATION *of* NITRE for this theory.

The

The goodneſs and force of gun-powder depend upon two eſſential points, firſt, that all the contained nitre be inflamed; and ſecondly, that this inflammation be made in the ſhorteſt time poſſible, and almoſt in an inſtant.

The proper quantities of ſulphur and of charcoal in the compoſition of nitre procure the inflammation of all the contained nitre; and the quickneſs and force of this inflammation depends upon the intimacy and accuracy of the mixture of the component parts of the powder.

From experience we find that the proportions of the ſeveral ingredients mentioned above are the beſt, that is, that they are ſufficient for the detonation of the whole nitre. A larger quantity of ſulphur and charcoal would leſſen the force of the powder; becauſe altho' theſe ſubſtances be inflammable, yet the force of their inflammation is nothing in compariſon of detonating nitre. Care muſt be taken that no uninflammable matters be mixed with the gun-powder, and therefore the nitre muſt be very well purified, and freed from the common ſalt mixed with it, which is not inflammable; and alſo from the ſalts with earthy baſes, which are contained in the mother water of nitre, and which have the bad quality of attracting powerfully the moiſture of the air, as this quality renders theſe ſalts capable of ſpoiling powder, in other reſpects good.

The quickneſs of the inflammation of gun-powder depends not only on the purity of the nitre and on the juſt proportion of the ingredients, but alſo on the accurate diſtribution, and the intimate mixture of theſe. The reaſon of this is very evident. As the ſalt-petre cannot be inflamed but by means of immediate contact with ſome inflammable matter, we may eaſily perceive that the finer the particles are of the ſalt-petre, and alſo of the ſulphur and charcoal, and the more intimately theſe three ingredients are mixed, the greater is the number of the points of contact, ſince the ſurface of each of the ingredients is thereby encreaſed; and hence the quicker the detonation muſt be. Accordingly all the operations in the making of gun-powder are to compleat theſe two intentions.

For this purpoſe, nitre of the third boiling, and well purified, is choſen, and alſo very pure ſulphur and good charcoal. The charcoal of light woods is generally employed; but Mr. Beaumé, who has very minutely and accurately examined this matter, affirms from experience, that the charcoals of heavy and hard woods, if they have been well made, are as fit for the purpoſe. Theſe three ingredients are mixed in the proportions above-mentioned, and a very fine diviſion and intimate mixture are made of them, by pounding them together, during twelve hours, in a wooden mortar, and with a wooden peſtle. This mixture muſt be carefully moiſtened from time to time with ſome water, to prevent the matters when too dry from being raiſed and diſſipated by this long trituration, and to prevent the mixture from kindling by the heat occaſioned by the repeated ſtrokes of the peſtle. In large works, a mill is employed for this trituration, in which wooden mortars are diſpoſed in rows, and in each of which a peſtle is moved by the arbor of a wheel turned by water, as in paper mills.

When the trituration is finiſhed, the powder is made. Nothing then remains to be done but to dry it very ſlowly, but compleatly. The powder is in this ſtate compoſed of very fine parts, which are therefore liable to moiſten in the air,

air, to adhere to any thing, to soil the fingers and the inside of fire-arms, into which also it does not easily slide. These inconveniencies are remedied by reducing it to small smooth grains, larger for cannons, and smaller for muskets.

The operations by which the powder is reduced into grains are very simple, and well imagined. For this purpose, it is placed to a certain thickness upon sieves, the holes of which are of a proper size; upon this stratum of powder a thick piece of wood is placed horizontally, and presses upon the surface of the powder. All this apparatus is to be agitated horizontally in several directions. The weight of the piece of wood forces the powder to pass through the holes of the sieve, and to form itself into molecules of the size of the holes. The powder is by this method granulated, but it is not rendered smooth. In its rough state it is used for artillery; but for small arms it must be smoothed, and this is effected by an operation as simple as the preceding.

For this purpose a hollow cylinder or cask is mounted upon an axis, which is to be turned by a wheel. This cask is to be filled half full of the powder to be smoothed, and it is to be turned six hours. The friction occasioned by this motion of the parts of the powder against each other is sufficient to smooth their surfaces. The granulation and smoothing of the gun-powder cannot be performed without a part of it being reduced to a fine powder, which is to be separated from the rest by a searce, and to be afterwards granulated. Those who require more particular information concerning this manufacture, or other arts and trades, may consult the *Dictionnaire portatif des arts & des metiers. See the articles* ACID (NITROUS); NITRE; DETONATION *of* NITRE; SULPHUR; COAL. (*d*)

DLV. POWDER *of the* CHARTREUX. *See* KERMES.

DLVI. POWDER (FULMINATING). This powder is a mixture of three parts of nitre, two parts of the dry alkali of tartar, and one part of sulphur. It is called fulminating, because when it is put upon a gentle fire, in an iron spoon, and slowly heated, it detonates with astonishing violence and noise as soon as it receives the proper heat.

The most remarkable circumstances in this experiment are, that this powder does not require to be forcibly confined, as gun-powder does, to make a great

(*d*) Mr. Beaumé analysed a pound of the gun-powder made for the French ordnance. By boiling it in water he extracted 12 ounces of salt petre; and by exposing the residuum to a heat just sufficient for the slow combustion of the sulphur, he found that it contained two ounces of sulphur and two ounces of charcoal.

Some persons, misled by an experiment of Dr. Hales, which shews that burning sulphur does not generate elastic air, but destroys the elasticity of common air, have imagined that the sulphur was an unnecessary and even hurtful ingredient of gun-powder. Mr. Beaumé, having made experiments on that subject, found that by addition of the sulphur, the force of gun-powder was nearly doubled.

The use of sulphur, as an ingredient in gun-powder, seems to be not to encrease the explosion immediately by its own combustion, but to accelerate the combustion of the other ingredients, which it does by its property of being much more easily inflammable than the charcoal. The charcoal not only concurs with the sulphur in supplying the inflammable matter which causes the detonation of the nitre, but also considerably adds to the explosive power of the detonating nitre, by the quantity of elastic vapor expelled during its combustion. Concerning the whole explosive force of gun-powder, *see a Note subjoined to the article* DETONATION *of* NITRE.

explosion,

explosion, and also that heat must be applied slowly; for the fulmination is less strong when the powder is hastily heated; and although a single gros *(e)* of this powder is sufficient, when heat is slowly applied, to make a noise as considerable as that of a cannon, and to produce an explosion dangerous to bystanders; yet a much larger quantity may be thrown upon lighted coals without danger, and even without explosion, because the nitre does then only gently detonate, as it does when it is alkalised by charcoal.

The explanation of these singular effects is deducible from the theory of the detonation of nitre. The explosion produced by nitre, when inflamed with any combustible matter, is so much stronger as the quantity inflamed at once is larger, so that it is the strongest possible when all its parts kindle at once, and instantaneously: but this happens in the experiment of fulminating powder. When it is very slowly heated, it is first liquefied: a kind of liver of sulphur is formed by the combination of the alkali with the sulphur which enters into the composition of this powder; the phlogiston of the sulphur is almost entirely disengaged, and reduced into a vapor which penetrates the mass on all sides, and is equally distributed betwixt the parts of the nitre, which is then also fused. Lastly, when the heat is strong enough to kindle any part of the powder when brought to this state, all the others kindle also; both because, by having been slowly heated, they have nearly the same degree of heat, and also because they are all disposed in the most advantageous manner to inflammation. They therefore all kindle at the same time; and this instantaneous explosion strikes the surrounding air with such violence and rapidity, that this fluid has not time to give way to the sudden percussion, and consequently resists as much the fulmination of this powder, as the chamber of a gun resists the fulmination of gun-powder. Hence fulminating powder does not require to be closely confined, as gun-powder does, to make a much more considerable noise.

This circumstance also is peculiar to fulminating powder, that some instants before its explosion, a light blue flame appears upon its surface; which is nothing else than the phlogistic vapors beginning to kindle. No more fire or flame is perceptible during its fulmination: this proceeds from the quickness of the explosion, and the violence of the commotion of the air, by which the flame is extinguished and suffocated as soon as it is formed, and before it can be perceived. Hence also fulminating powder does not generally kindle the combustible bodies in contact with it, because the time of its inflammation is too short.

This powder differs in these two last phenomena from gun-powder, but they are common to it with fulminating gold. If we were certain that *nitrous sulphur* can subsist ready formed uninflamed, these effects would induce us to believe that it subsists already combined in fulminating powder and in fulminating gold, some time before their explosion, as Mr. Beaumé thinks. We cannot be certain of this, unless we could obtain nitrous sulphur single and uninflamed, as we can vitriolic sulphur and phosphorus. *See* Acid (Nitrous), Nitre, Detonation *of* Nitre, Liver *of* Sulphur, Gold (Fulminating), Powder (Gun), *and* Sulphur.

(*e*) A gros is 72 grains.

DLVII. PRECIPITATION, *and* PRECIPITATES.

Precipitation is one of the moſt general and important operations of chemiſtry. The term *precipitation*, in its moſt extenſive ſenſe, is applicable to all chemical decompoſitions made by an intermediate ſubſtance, that is, to all operations in which two bodies are diſunited, by employing a third body which has the property of uniting with one of theſe, and thereby of ſeparating the other. Hence we ſee that every precipitation is effected by means of the affinity of a precipitant, much ſtronger than that of the precipitate with the ſubſtance from which it is ſeparated. This is the third caſe of affinity; when three ſubſtances act upon each other. *See* AFFINITY.

This ſurprizing property that certain ſubſtances poſſeſs of ſeparating others ſtrictly united, is the true efficient cauſe of many chemical decompoſitions which could never have been performed by other means. Thus, for inſtance, we ſhould never have known the acid of ſea ſalt, ſedative ſalt, and many other very important ſubſtances in chemiſtry, without the aſſiſtance of ſome acids more powerful than theſe, and capable of ſeparating them from the baſes to which they are united.

Although all theſe decompoſitions eſſentially belong to precipitation, yet uſe has confined this term to thoſe operations only in which the ſubſtance becomes palpable when it is ſeparated, and conſequently falls by its gravity to the lower part of the veſſel in which the operation is made. From this fall of the ſeparated ſubſtance the operation has been called *precipitation*; and the ſubſtance ſeparated, and collected at the bottom of the veſſel, has been called *precipitate*.

We ſhall not ſay any thing here concerning the cauſe of precipitation, becauſe our knowledge is not yet ſufficiently extenſive to enable us to affirm any thing upon the ſubject. An hypotheſis relating to it may be found under the article GRAVITY. In this article we ſhall only mention the principal phenomena of precipitations, and the moſt eſſential properties of ſeveral precipitates.

Precipitation is never occaſioned but in fluid matters; and as bodies may be rendered fluid either by fire or by water, two kinds of precipitations may be diſtinguiſhed, one by the humid way, and the other by the dry way. In the firſt claſs ought to be ranged all decompoſitions of ſalts with earthy or metallic baſes, which ſalts muſt be diſſolved in water when their baſes are to be ſeparated from their acids by proper intermediate ſubſtances. The ſecond claſs includes the ſeparations of metals and of other ſolid and fuſible matters from each other, which are effected by fuſion and mixture with the ſeparating ſubſtances. Theſe two kinds of precipitation do not eſſentially differ: but many real differences diſtinguiſh the ſeparated ſubſtances, or all thoſe to which the general name of precipitate is given. This name has been given very improperly to ſeveral preparations which are not precipitates. Such are the *red precipitate*, *precipitate per ſe*, and ſome others. And amongſt the preparations which may properly be called by this name, becauſe they are ſubſtances ſeparated from other ſubſtances by intermediate bodies, many do eſſentially differ from others, and ought therefore to be diſtinguiſhed by different names.

When

When a body is decomposed by means of an intermediate substance, and a precipitate is formed by this decomposition, this precipitation can be effected only by the intermediate substance uniting with one of the component matters of that body; and consequently a new compound is always formed in these operations. Sometimes the separated matter, being no longer soluble, becomes sensible, and falls as a precipitate, while the new compound remains dissolved. In other instances, the separated substance remains dissolved, while the new combination, not being soluble, is precipitated. This depends on the nature of the substances which act one upon another in these operations; but we may easily perceive that the precipitates of the former kind are simple, and those of the latter are compound.

Some modern chemists consider these simple precipitates only as true precipitates, or which ought to be so called. Nevertheless, we must acknowledge that precipitates of the second kind have all the requisites to entitle them to the name of precipitate; and no inconvenience attends the giving to them that name, provided they are distinguished from the former kind by the denomination of *compound precipitates*.

Earths and metals, when separated from acids by means of alkalis or other metals, are simple precipitates, and when separated from acids by other acids, are compound precipitates. For instance, calcareous earth united with nitrous and marine acids may be separated from these by the vitriolic acid: and if this separation is effected by pouring vitriolic acid into a solution of nitre or of marine salt with calcareous basis, the liquors which were before clear will by this addition of vitriolic acid be rendered turbid and milky, and a sediment or white precipitate will soon be formed at the bottom of the liquor. This precipitate is nothing else than the calcareous earth which was united with the nitrous or marine acids, and which being separated from these acids by the vitriolic acid, unites with this latter and forms a new compound, a selenites, the greatest part of which, not being capable of remaining dissolved in the liquor, is precipitated. *See* SELENITES.

In the same manner, when vitriolic acid or any salt containing it is mixed with a solution of silver, of lead, or of mercury by the nitrous acid, a precipitate is soon formed, which is a combination of the metal with the vitriolic acid. *See* VITRIOLS.

The same thing may be said of the corneous metals, which are combinations of these metals with marine acid, by which they have been separated from nitrous acid. *See* LUNA CORNEA, *and* PLUMBUM CORNEUM.

All the precipitates above-mentioned are really new combinations of the precipitated substance with the precipitating acid; and which only separate from the liquor, and appear as precipitates, because they are are not very soluble, and the liquor contains too little water to keep them suspended. This may be proved by adding a sufficient quantity of water, by which this kind of precipitates will be entirely dissolved. Nevertheless this circumstance does not prevent their being precipitates, when they are actually made by precipitation. For amongst the precipitates considered as simple, and to which many chemists would confine the name of precipitate, perhaps there is not one really simple. Modern chemists have observed, that all precipitates in general draw along with them a greater or less quantity of some other substances during

the precipitation. They either retain a part of the substance with which they were united before precipitation, or a part of the precipitant, and frequently even a certain quantity of each of these matters. This depends on the nature of the bodies which act upon one another, on their proportions, and on concomitant circumstances. If any precipitates can be considered as pure and simple, certainly a metal precipitated from an acid by another metal may, as, for instance, silver and mercury separated from the nitrous acid by copper, or copper separated from acids by iron; because the precipitated metal resumes its natural color, lustre, and metallic properties. Nevertheless, when we subject these metallic precipitates to accurate trials, we discover that they are allayed with a small quantity of the precipitating metal. In general, precipitates and the different circumstances of precipitation have been hitherto but superficially examined. It is a subject no less important than new, which deserves attention, and is replete with many discoveries.

After these explanations which we thought necessary concerning precipitation and precipitates in general, we proceed to treat of the principal chemical preparations called precipitates; because these which are not called precipitates, although they really be so, are treated of under other articles.

MERCURIAL PRECIPITATES.

DLVIII. PRECIPITATE (WHITE). This is mercury separated from nitrous acid by marine acid, with which it then unites. White precipitate is made by pouring a solution of common salt in distilled water into a solution of mercury in nitrous acid, till no more precipitate falls. When the sediment is collected at bottom, the supernatant liquor is to be decanted, and the precipitate is to be washed several times with distilled water, and then dried.

This precipitate of mercury is one of those called compound. It is a combination of mercury with the acid of common salt; for in this operation, as well as in the precipitation of the corneous metals, the metallic matter is only separated from the nitrous acid by means of the combination it forms with the marine acid. In this precipitation, then, the phenomena are similar to those which happen in the formation of luna cornea and plumbum corneum. 1. White precipitate may be made by pure marine acid. 2. When it is made by common salt, or other salt containing marine acid, two decompositions happen, and two new combinations are formed. The nitrous acid which was originally united with the mercury combines with the substance that was united with the marine acid, and forms a new nitrous salt, which remains dissolved in the liquor. When common salt is employed, cubic nitre is formed. If marine salt with an earthy basis is used, the liquor after the precipitation, contains a nitre with earthy basis. Upon this subject *see the article* AFFINITY. 3. All the mercury, although entirely separated from nitrous acid and united with marine acid, is not precipitated in the present occasion, because it is reduced to a saline compound essentially soluble in water; and consequently the liquor contains as much of it as it can dissolve, and another part of it is dissolved by the water employed to wash it. Similar events happen also in the precipitation of silver and of lead by marine acid. Accordingly, if an alkali be added to clear the liquor decanted from these precipitates, or even to the water employed to wash them, another precipitate will be formed; but this latter

latter is of a different nature, and is ſimple in compariſon of the former, ſince it does not contain any acid combined directly with the metallic ſubſtances, or, at leaſt, much leſs of the acid.

Lemeri gives another proceſs for making a white precipitate, which conſiſts in diſſolving four ounces of ſal ammoniac in a pound of water; to which is to be added an equal quantity of corroſive ſublimate; all which could not be entirely diſſolved alone in that quantity of water, but may by means of the ſal ammoniac. *See* SUBLIMATE (CORROSIVE), *and* TINCTURE *of* MERCURY. Into this ſolution liquid fixed alkali is to be added, till no more is precipitated. The precipitate is very white, and it has been accordingly called white precipitate by ſeveral chemiſts; but it ought not to be confounded with the white precipitate formed by adding marine acid or common ſalt to a ſolution of mercury in nitrous acid; for they are evidently very different.

We may remark, that the color of this precipitate of Lemeri is influenced by the ſal ammoniac; for although this precipitate be very white, the precipitate formed by adding fixed alkali to a ſolution of corroſive ſublimate in water is brick-colored. The whiteneſs of the former precipitate then proceeds from the great quantity of marine acid, and even of the volatile alkali of the ſal ammoniac, which affect this precipitation. This proves, that precipitates reputed ſimple are not ſo; and that they draw along with them part of the ſubſtances to which they were united, and of the precipitating ſubſtances. Great differences may be obſerved in this reſpect amongſt precipitates in general, according to the quantity and proportions of ſubſtances which concur to the precipitation.

DLIX. PRECIPITATE (YELLOW). As chemiſts have given many different forms to mercury, to adapt it to medicinal uſes and to chemical proceſſes; ſo they have made various precipitates of it, and have given the name of precipitate to other mercurial preparations which in fact are not precipitates. These are chiefly denominated from their colors, without adding any epithet to ſhew that they are mercurial. Thus *white precipitate*, *yellow precipitate*, *red precipitate*, &c. are preparations of mercury. Yellow precipitate is mercury diſſolved by vitriolic acid, from which it is afterwards ſeparated by addition of water alone; it is then in form of a yellow powder: but as this precipitate is better known by the name of TURBITH MINERAL, we ſhall treat of it under that article.

DLX. PRECIPITATES (BLACK *and* ROSE-COLORED). Lemeri, who mentions many precipitates of mercury of different colors, ſays, that if a ſolution of mercury in ſpirit of nitre be precipitated by urine, inſtead of a ſolution of common ſalt, a roſe-colored precipitate of mercury will be formed; and that if afterwards ſome fixed or volatile alkali be added to the liquor from which the roſe-colored precipitate has been formed, another precipitate which is black will be obtained.

Much common ſalt being contained in urine occcaſions the roſe colored precipitate, which is eſſentially the ſame as the white precipitate obtained by pure ſea-ſalt or marine acid. The redneſs of its color probably proceeds from ſome reddiſh earthy or ſaline-earthy matter contained in urine, which it draws along with it.

The

The blackneſs of the precipitate obtained afterwards by adding alkali proceeds from the oily and phlogiſtic parts of the urine, which are added ſuperabundantly to the mercury, and which always blacken white metals, as ſilver, lead, biſmuth, theſe metals being ſuſceptible of receiving inflammable matter ſuperabundantly, when they are expoſed to vapors of ſulphur, of liver of ſulphur, or when they are precipitated by this latter ſubſtance. *See* LIVER *of* SULPHUR.

DLXI. PRECIPITATE PER SE. This preparation of mercury is very improperly called a precipitate; becauſe it is not ſeparated from one ſubſtance by means of another ſubſtance, as all true precipitates are, but is only mercury reduced to a red powder by a kind of calcination.

To make this preparation, three or four ounces of mercury are put into a flat-bottomed glaſs matraſs, the neck of which is very long, and the opening of a capillary ſize. This matraſs, the belly of which ought not to be entirely full of mercury, is to be placed in a ſand-bath, and heated till the bottom of the veſſel containing the ſand be red-hot. This heat is to be continued during two or three months. The mercury gradually loſes its luſtre, and part of it is converted into a red powder, which does not mix with the remaining fluid mercury, but floats upon the ſurface of the mercury, or adheres to the ſides of the veſſel. The operation may be ſhortened by uſing a greater number of matraſſes, all which may be placed in the ſame bath. When enough of this red powder is obtained, it is to be collected and ſeparated from the remaining fluid mercury. This is called *precipitate per ſe*, or *by itſelf*, or *red precipitated mercury without addition*.

This preparation of mercury we have received from the alchemiſts, who ſpared no pains nor labor to change mercury and to fix it. They received great hopes from the change of color, the want of fluidity, and the diminution of volatility which the mercury ſuffers by this operation. Although the mercury is much diſguiſed by theſe changes, yet it is not eſſentially altered, becauſe it may be reduced to fluid mercury by heat without addition. We cannot preciſely explain the phenomena of this operation. Different opinions are formed concerning them. Mr. Baron conjectures, that they are cauſed by the union which mercury contracts by means of its being much divided with the ſaline particles contained in air. We ſee indeed from turbith mineral and red precipitate, that mercury is diſpoſed to take the form and qualities of the precipitate per ſe, by an union with a ſmall quantity of ſaline ſubſtance. Mr. Beaumé thinks, on the contrary, that the mercury is truly calcined, that it loſes part of its phlogiſton; and that, when it is expoſed to heat, it is again reduced to its metallic ſtate by the addition of the inflammable principle which paſſes through the containing veſſels, and again combines with it. This opinion is not improbable; but more experiments and reſearches are wanting to decide concerning it. I ſhould be, nevertheleſs, ſufficiently diſpoſed to believe, that a part of the inflammable principle contained in fluid mercury is ſuperabundant to it, ſlightly adherent, and may be eaſily loſt and recovered.

DLXII. PRECIPITATE (RED). If a ſolution of mercury in nitrous acid be reduced to dryneſs by evaporation, and the mercurial nitre thence formed be put into an open matraſs ſet in a ſand-bath, with a fire

gradually

gradually encreasing, the nitrous acid will disengage itself from the mercury, and evaporate in a red vapor. While the acid evaporates, the saline mercurial mass loses its original whiteness, becomes yellow, then orange, and lastly red.

This red matter, when separated from the matrass, (which must be broken for that purpose) and pulverised in a glass mortar, is the *red precipitate*, as it is improperly called; it not being a precipitate, but a mercurial nitre from which the greatest part of the acid is expelled by the fire, without the application of any intermediate substance. The red color of this preparation is caused by the great division of the molecules; for, from the example of the precipitate per se, and of several true mercurial precipitates, which also are red, we learn that this is the color assumed by mercury when it is not fluid, when its parts are much divided, and when it has not a superabundant quantity of phlogiston.

Notwithstanding the calcination which mercurial nitre sustains in this operation, all its nitrous acid is not expelled. The mercury still retains a quantity of acid equal to the ninth part of its weight, as Mr. Lemeri observes. This preparation is therefore corrosive, and only used externally. Several authors propose to render it milder by burning spirit of wine two or three times over it. It is then called *arcanum corallinum*, and has been given by some physicians internally. If it be indeed rendered milder by this inflammation of spirit of wine, the effect must be produced by a partial reduction of the mercury, occasioned by some phlogiston which it receives from the spirit of wine; but the internal use of this precipitate is abolished, because the effects of other preparations are more uniform and certain.

Red precipitate is much less volatile than crude mercury. Nevertheless, by a strong fire in close vessels it may be sublimed entirely, and the sublimate has the same color and other qualities as the precipitate. As nitrous acid is a very powerful agent to deprive bodies in general, and particularly metallic substances, of part of their phlogiston; and as red precipitate has all the appearance of a mercury partly deprived of its inflammable principle; I have endeavored to calcine it further by leaving it exposed a long time to fire, and by dissolving it many times in fresh nitrous acid. For this purpose I digested during four days some red precipitate with a strong heat, which I then dissolved in more nitrous acid, afterwards restored it to the state of red precipitate, and then calcined it again during four days. Eight times I repeated these calcinations and solutions; but when I examined my mercury, it appeared to be just the same as it was after the first solution and calcination. This determined me to relinquish the experiment. It proves, that if the nitrous acid does deprive the mercury of any of its phlogiston, the quantity of this principle is very small which it thus detaches, and is only that which is but little adherent and superabundant. It also proves, that nitrous acid takes as much phlogiston from the mercury the first time as it can; and that therefore any attempts to dephlogisticate it perfectly would be unsuccessful by this, or probably by any other method, since this seems to be the most effectual.

Lemeri observes, that many authors have believed that the color of red precipitate might be much heightened by thrice cohobating and distilling the white mass above-mentioned with spirit of nitre; and he affirms, that this effect

is not produced by these operations. This experiment is similar to that I have mentioned, but is less capable of changing the mercury, because it is not calcined after each distillation. I have also remarked, that red precipitate is easily soluble, and produces heat, but no effervescence, with new nitrous acid. Lemeri observed the same phenomenon with vitriolic acid.

DLXIII. PRECIPITATE (GREEN); *and* PRECIPITATE (BLACK), *or* VIOLET-COLORED MERCURY. Some authors, particularly Lemeri, give processes for other preparations of mercury, which have been employed as remedies, and which are improperly called *precipitates*. Such is green precipitate, which is a mixture of four parts of mercury and one part of copper, dissolved separately in the nitrous acid, and treated as in the process for making red precipitate; afterwards, partly dissolved a second time by being digested with vinegar; and, lastly, reduced by evaporation to a dry consistence. Such also is the preparation called by Lemeri *violet mercury*, or *black mercurial panacea*, or *black precipitate*, which is an artificial cinnabar overcharged with sulphur, mixed with sal ammoniac, and prepared by a very long and laborious process: but as these preparations have been made only for the use of medicine, and have fallen into disrepute, we shall not say any more of them, excepting that they are singular mixtures, accompanied with many unforeseen appearances, which could not be explained without further examination and particular dissertations. *See the article* MERCURY *for the medicinal virtues of all the mercurial preparations called precipitates.*

DLXIV. PRECIPITATE *of* GOLD *by* TIN, *or* PURPLE POWDER *of* CASSIUS. This precipitate of gold may be made by several methods: but which of these is the best, has not yet been decided. The cause of this uncertainty is, that the preparation requires delicate management, and is uncertain in its result, the beauty of the color seeming to depend on some small circumstances not yet discovered; for we find that the color of the powder obtained frequently varies, notwithstanding the processes seem to have been the same. I have tried several methods. The following is what has best succeeded with me, and is nearly the same as that described by Mr Gellert in his Metallurgic Chemistry.

Make an aqua regia with two parts of spirit of nitre and one part of spirit of salt; dilute this acid with an equal quantity of distilled water; add to it a small piece of Malacca tin, and let it be dissolved without heat. If the weather be cold, the time employed in this solution will be long; but this is rather an advantage than an injury. When this piece of tin is entirely dissolved, add another, and let it be dissolved in the same manner; continue to add more pieces of tin, one at a time, till the liquor has acquired a yellow color, and almost ceases to act upon the tin; then decant the liquor from the remaining piece of metal.

Also dissolve gold of 24 karats in an aqua regia composed of three parts of spirit of nitre, and one part of spirit of salt. This solution may be accelerated by the heat of a sand-bath.

Dilute the solution of tin in a hundred times its quantity of distilled water. Try your solutions in the following manner: Take a small quantity of the diluted solution of tin; divide it into two parts; to one of which add a known

quantity

quantity of distilled water: to each of these portions of the solution of tin add a drop of the solution of gold, by which they will acquire a red purple color: observe which of the colors of the two solutions is the finest, and keep to that degree of dilution for the rest of the solution of tin: to the solution of tin thus diluted add such a quantity of the solution of gold, that there shall be in the mixture two parts of the former metal to one of the latter: stir well the mixture (which ought to be made in a large glass vessel) with a glass rod. The whole will acquire the color of red wine, and a sediment will gradually be deposited of the same color, while the liquor will become clear. Then pour into this clear liquor some drops of the solution of tin, and observe if any more gold is precipitated: when the liquor is very clear, decant it gently from the sediment, which is to be well washed with pure distilled water. This is precipitate of gold, or the purple powder discovered by Cassius. It is a valuable preparation, because it is the only one known capable of giving a red purple or crimson color to glass, enamel, and porcelain. When it is to be used, it must be well mixed, and ground with a fusible glass, as Venice glass; and this mixture is to be exposed to the degree of heat necessary for melting the glass. If a colored glass or artificial ruby be required to be made, so large a quantity of glass is to be added to the mixture that the gold shall not destroy its transparency: but for enamel painting, a smaller quantity of glass is required, that the color may be intense. The particular proportions cannot be ascertained, because the intensity of the color given by the gold is very variable.

We have already remarked, that this preparation is subject to varieties; and that by the same process it is sometimes more and sometimes less beautiful. Sometimes we can obtain only a precipitate of a black violet color; at other times we can obtain scarcely any color, without being able to discover the reason of these differences. We know, however, many essential circumstances concerning the success of the operation. We are certain, that little or no purple precipitate will be formed when the tin has been quickly dissolved, and with heat and effervescence. To understand the reason of this, we must recollect the following principles.

First, the gold is really precipitated in this experiment; for the purple powder may be reduced to gold. Besides, we know that this metal, when much divided and united with some saline parts, or perhaps even with a superabundant quantity of phlogiston, has always a reddish-purple or violet color.

Secondly, the gold is here precipitated only by means of the tin; because this latter metal has a stronger affinity than the former with the acids of aqua regia; and although it already is united with the same acids, it yet seizes those superabundantly that keep the gold dissolved, which it therefore precipitates. This proposition is proved by observing, that nothing else is added to the solution of gold in the preparation of the purple powder, than tin, aqua regia, and water; but as no quantity of aqua regia and water can occasion this precipitate, the tin therefore is the substance which does occasion it. Besides, gold may be formed into a purple precipitate by adding a piece of tin to a solution of gold in aqua regia. If a question be asked, Why, when we employ a solution of tin, that is, tin united with so much acid that it remains dissolved in much water, this tin should nevertheless seize upon the acids which keep the gold dissolved? the reply is, That tin is capable of charging itself with a

 larger

larger quantity of acid than is necessary to dissolve it; and also, that when its solution is diluted in a large quantity of water, more acid is required to keep the metal dissolved: for when a great deal of water is added to a clear solution of tin, the liquor will become turbid, and the tin will be precipitated. We cannot then be surprized that the tin, which in this dilute solution is on the point of precipitating before the solution of gold is mixed with it, and which then has scarcely a sufficient quantity of acid to keep it dissolved, should, when that mixture is made, seize the acids of the solution of gold.

Thirdly, we know that metals are capable of being dissolved in acids by means of their phlogiston. We know also that acids, and particularly the nitrous, take from the imperfect metals a part of their phlogiston during the solution of these metals, and that this loss of phlogiston sustained by metals is so much more considerable as the solution is made with more activity, quickness, and heat. Tin is more subject to lose its phlogiston than any other metal; hence it cannot continue suspended in the nitrous acid, which takes so much of its phlogiston from it, that it is soon reduced to a white calx: although the marine acid, a large quantity of which is in the solution of tin employed for the preparation of the purple powder of Cassius, considerably moderates the action of the nitrous acid, and prevents so compleat a dephlogistication as is occasioned by pure nitrous acid; nevertheless, when this solution is performed with too much activity, the tin is too much calcined, part of it is often precipitated in form of a white calx, and the remaining part which is dissolved contains so little phlogiston, that the acids of the solution of gold cannot act properly upon it: hence such a solution of tin is unfit for the preparation of the purple precipitate of Cassius, and it frequently is incapable of forming it: hence we see the reason why the success of the operation depends so much on the slowness with which the tin is dissolved.

The solution of tin must be diluted in much water, else a fine color will not be produced. The reason of this is, that the tin is so much more capable of precipitating the gold, as by the dilution of the acids with which it is united, it is more disposed to fall down spontaneously. Accordingly, a certain quantity of tin is always precipitated along with the gold, which appears in form of a white calx.

The solution of tin in aqua regia is not the only substance with which a purple powder of gold may be made. We have already seen, that a small piece of tin put in a dilute solution of gold forms a purple precipitate Orschal mentions this and several other very curious experiments on the same matter, in his little Treatise called *Sol sine Veste*. For instance, we there find that the smoking liquor of Libavius makes also a purple precipitate. I have found that tin dissolved in marine acid likewise makes it. The same chemist further says, that a solution of mercury in spirit of nitre mixed with a solution of gold produces a more beautiful precipitate than tin; that fulminating gold, that gold itself when much divided, like the powder scraped off a piece of gold by pouncestone, being mixed and melted with vitreous matters, make a red glass. These facts prove, that this color is natural to gold, whenever it is very much divided.

This purple powder appears to have been a secret and a novelty in the time of Orschal; as he says that he learnt it from Cassius himself. Several cotem-

porary chemiſts believed, that the gold was decompoſed in this operation, and vitrified in the red glaſs which received its color from it: but Orſchal, leſs diſpoſed to the marvellous, becauſe he was more intelligent, remarks, that the gold is not decompoſed, and only is leſs eaſily reducible than when under another form; which is a true explanation. *See* TIN *and* GOLD. (*f*)

DLXV. PRINCIPLES. This name is given to ſubſtances obtained from compound bodies, when their analyſis or chemical decompoſition is made.

Philoſophers and chemiſts have long ago diſcovered, that almoſt all natural bodies are capable of being reduced to a greater or leſs number of other bodies leſs compounded, ſimilar to each other, and almoſt the ſame, of whatever nature the body was from which they were ſeparated. This important obſervation has induced a belief, that the innumerable productions of nature were only the reſults of the combination of a few more ſimple ſubſtances, the different proportions and arrangements of which formed the diverſity of all compound bodies. Theſe laſt bodies retain the name of *compounds*; and the more ſimple ſubſtances, from the union of which theſe compounds reſult, are called *principles*: but as the number and nature of the principles of bodies can only be diſcovered and aſcertained by many laborious chemical experiments, and as in theſe latter times only, chemiſtry has been properly cultivated as a part of natural philoſophy, ancient philoſophers could only give vague conjectures concerning the number and nature of the principles of bodies. Accordingly,

(*f*) Long cylindrical pieces of glaſs, called *Jews glaſs*, are commonly ſold, and much uſed by manufacturers of glaſs-toys. This glaſs, though perfectly colorleſs, yet when it is expoſed to the heat and flame of a lamp, acquires a beautiful ruby color, exactly ſimilar to that of pure glaſs melted with powder of Caſſius. As no other known ſubſtance but gold gives that color to glaſs, we may preſume that this glaſs contains ſome of that metal; in which caſe, the gold appears to be vitrified, and more changed than in any other known preparation of it. Kunkel ſays, that having occaſion frequently to make this ruby glaſs, he had ſometimes obſerved the glaſs, when taken out of the crucible, inſtead of being colored as uſual, to appear colorleſs as cryſtal, and to acquire a ruby color by expoſure to the flame of a lamp.

Dr. Lewis obſerves, that though a purple or a ruby color may eaſily, by the methods publiſhed, be applied upon glaſs or enamels, and introduced into the maſs by fuſion, the way of equally diffuſing ſuch a color thro' a quantity of fluid glaſs is ſtill a ſecret. That author ſays, that he has made ſeveral trials of this kind, in one of which the glaſs was uniformly tinged of a ruby color; and in the others various colors, as yellow, red, and brown, appeared, and were unequally diffuſed: but he had not diſcovered the circumſtances upon which theſe differences depend. Orſchal, in his Treatiſe *Sol ſine Veſte*, gives a proceſs by which he obtained a fine ruby glaſs. He directs, that the powder of Caſſius ſhould be ground with ſix times its quantity of Venice glaſs finely powdered; and that this mixture ſhould be well mingled with a fritt conſiſting of equal parts of borax, nitre, and fixed alkaline ſalt, and four times as much calcined flint as of any of the ſalts: but he does not mention the proportion of the powder of Caſſius to the fritt, nor in what manner the fuſion is to be performed.

Kunkel ſays, that one part of the powder of Caſſius is ſufficient to give a ruby color to twelve hundred and eighty parts of glaſs.

Dr. Franklin obſerves, that gold-leaf placed betwixt two plates of glaſs being expoſed to an electrical ſhock, ſtained the contiguous glaſs with red ſpots, which were ſunk into the body of the glaſs.

ingly, in each school of philosophy different opinions prevailed concerning these principles, some of them admitting one only, and others more: some asserting that water was the principle of all things; some contending for earth, and others for fire. We do not intend to discuss all these opinions; but shall only observe, that almost all the ancient philosophers have been mistaken from a want of a sufficient number of chemical experiments and observations.

The chemists of the middle ages, that is to say, about the time of Paracelsus, had very confused notions concerning this matter. They admitted five principles of bodies, which they called *mercury* or *spirit*, *phlegm* or *water*, *sulphur* or *oil*, *salt*, and *earth*. By *mercury* they probably meant whatever is volatile, and which in the analysis of bodies is capable of affecting the taste and smell. This conjecture is confirmed by the name *spirit*, which they also gave to the same principle. Their *phlegm* comprehends all the watery uninflammable products obtained in the analysis of bodies. By *sulphur* they meant not only sulphureous matters and common sulphur, but also any oils, and all the inflammable matters obtained in the decomposition of bodies. All saline matters obtained in these analyses were comprehended under the general name *salt*. Lastly, they applied the word *earth* to the fixed matters which remain after the analysis of bodies. We shall afterwards see that some of these principles, which are called the principles of Paracelsus, are simpler than others; hence obscurity and confusion have been introduced into the opinions formed concerning principles in general.

Beccher, perceiving this inconveniency in the principles of Paracelsus, attempted to reduce their number, and to give more precise notions of them. He established only two general principles of all bodies, namely, water and earth: but as he could not explain the properties of all compounds from these two principles, he admitted three kinds of earths, which he considered as equally simple and elementary. The first he called *vitrifiable earth*, which, according to him, is the principle of the fixity, of the solidity, and of the hardness of bodies. He called his second earth *inflammable earth*, which he supposes to be the principle of inflammability of all inflammable bodies. Lastly, the third earth of Beccher is called *mercurial earth*. He considered this earth as forming with the two others metallic substances, and he also admitted it as a principle in the composition of other bodies, particularly of the marine acid. This chemist gave the name *earth* to these three last mentioned principles, because he considered them as being of a dry nature, and as differing essentially from water, which he considered as a principle essentially humid.

The theory of Beccher concerning principles is very profound, and may be considered as the source of the most important discoveries of modern chemistry: but we must confess, that had not the illustrious Stahl commented upon this theory, illustrated and extended it, we might have received no benefit from it.

This excellent chemist easily shewed, that water and vitrifiable earth enter as elements into the composition of many bodies; for these two principles are sensible, and all the experiments of chemists shew their existence in most compounds: but the other two principles of Beccher, namely, his mercurial earth and his inflammable earth, have not, even yet, been exposed to our senses, single and pure; and therefore all the sagacity and genius of Stahl were required to demonstrate the existence and properties of this inflammable earth,

which

which we now call *phlogiston*, or *inflammable principle*, and which is nothing else than the very substance of fire when rendered a principle of bodies. *See* PHLOGISTON.

The existence of the mercurial earth is not satisfactorily demonstrated either in the works of Beccher or of Stahl. We have nothing but inferences and presumptive proofs of its existence. *See upon this subject* METALS *and* METALLISATION.

That earth, water, and fire enter into the composition of bodies as principles, may be considered now as demonstrated by Beccher and Stahl. The experiments of many philosophers and chemists, particularly Boyle and Hales, have shewn that air also enters into the composition of many bodies as a principle, and even in very large quantities. Thus if we add this fourth principle to the three others above-mentioned, we shall find to our surprize, that we now admit as principles of all compounds the four elements, fire, air, water, earth, which Aristotle taught were such, long before the knowledge of chemistry was sufficient to establish this truth.

In whatever manner bodies are decomposed, we always obtain these substances. They are the utmost limits of chemical analysis. As we cannot by any means decompose these further, we consider them as simple substances, (although perhaps they may not be so) and are therefore called *primary principles* or *elements*. *See* ELEMENTS, AIR, EARTH, FIRE, WATER, PHLOGISTON.

When we decompose most bodies, we cannot nearly reduce them to their elements or primary principles by a first analysis, especially when they are much compounded. We obtain from them substances more simple only, but still compounded of other principles, for a reduction to which another analysis is requisite. As these substances, although compounded of a certain number of principles, do themselves the office of principles in the composition of bodies less simple than themselves, they have been called *principiate principles*. The principiate principles have so much better title to this name, as they subsist in their state after they have been separated from a body, characterised by peculiar properties, unalterable but by a new analysis, and capable of reproducing by their union a compound entirely like that from which they were originally separated. Most chemical agents, as acids and alkalis, are of this kind.

In the analysis of very compound bodies, principiate principles of different degrees of simplicity, or rather such as are capable of being reduced to others more and more simple, may be thus obtained successively, by first, second, and third analyses; hence several kinds of principiate principles of different degrees of simplicity, and which consequently are, by a true gradation, principles of one another, have been distinguished. Modern chemists distinguish them by names which mark their order of composition. Thus substances which cannot be further decomposed, and which are considered as simple, are called *primary principles*. *Secondary principles* are those which result immediately from the union of primary principles. *Principles of the third order* are those which are composed of secondary principles; and so on.

We may also with propriety distinguish the principles of bodies by the names of *proximate principles* and *remote principles*, by applying the former name to the principiate principles obtained directly from a body by a first analysis, and

by applying the latter name to the principles obtained by a further decomposition of these proximate principles.

These distinctions will be rendered more intelligible by an example; for the subject of which let us chuse a neutral salt, such as nitre. We have demonstrated that this salt is a compound of the acid called *nitrous*, and of the fixed vegetable alkali, combined and saturated together. By a first analysis then of nitre we shall obtain this acid and this alkali, which are therefore the proximate principles of nitre. But neither nitrous acid nor fixed alkali are simple substances. By a further analysis of each of these, they may be decomposed into water, earth, fire, or inflammable principle. This acid and this alkali must then be considered as *principiate principles*. But as the substances obtained from them are unalterable, and cannot be further decomposed, they must be considered as *primary principles*; the acid and the alkali of the nitre are then immediately composed of primary principles, and they themselves are consequently principiate principles, or secondary principles, or *principles of the second order*. In this example the water, earth, and fire, are the remote principles of the nitre.

Altho' these several denominations and distinctions of principles more or less simple be just and useful for the illustration of many important points in the theory of chemistry, this science is not however sufficiently advanced to enable us to determine the number and kinds of principiate principles of different orders, and especially of the higher orders. We know but a few, which, we have strong reasons to believe, belong to the second order; such, for example, are saline substances, and the more simple acids and alkalis; but we are not entirely certain of this, because we have not been able to produce any of these substances from the union of the primary principles, in such a manner, that no doubt can be admitted. *See the articles* COMBINATION, ANALYSIS, DECOMPOSITION. *

DLXVI. PUMICE-STONE. (g)

DLXVII. PURIFICATION. By purification is meant any chemical operation by which substances required to be obtained pure and single are separated from other heterogeneous matters with which they happen to be mixed.

As the several chemical agents and other matters are generally more or less confounded, and even combined with substances of different natures; and as we require in many accurate experiments that they should be very pure, we must therefore apply the proper methods to give them the necessary degree of purity.

But these methods differ very much according to the nature of the substance to be purified. They must be appropriated to their peculiar natures, and also to the nature of the substances to be separated. For the several purifications, we are obliged to employ almost all the operations of chemistry. Hence many operations are only true purifications, altho' they are not so called. For instance, all the second distillations and sublimations called *rectifications*, are nothing else than purifications. They are employed for the purification of volatile sub-

(g) PUMICE-STONE is a light, porous, spongy stone, resembling the scoria of furnaces. Its colors are white, yellowish, brown, or black. It is found near volcanos, and is believed to be a substance reduced to a burnt or semi-vitrified state by subterranean fire. Wallerius conjectures that it is the ashes of fossil coals thus changed by fire. Pumice-stone is fusible by intense heat.

ſtances from others that are fixed, or leſs volatile. In this claſs may be ranged the rectifications of oils, of volatile ſpirits and ſalts, of ardent ſpirits, and even of mineral acids; and the ſublimations of ſulphur, of arſenic, of cinnabar, of ſalt of amber, of flowers of benjamin, and of ſal ammoniac. *See* RECTIFICATION *and* SUBLIMATION. Alſo the repeated ſolutions, filtrations, evaporations, and cryſtallizations of neutral ſalts are only means of purifying them. *See* CRYSTALLIZATION, *and* SALT (NEUTRAL). Several calcinations, and particularly thoſe of fixed alkalis, are intended merely to purify them, by depriving them of a greaſy matter or ſuperabundant inflammable principle. *See* CALCINATION, *and* ALKALI (FIXED). Many ſolutions and precipitations by the humid way, particularly in the operations of parting, and of luna cornea, are performed for the purification of the perfect metals from their allay. Laſtly, the repeated fuſions of metallic ſubſtances, the ſmelting of ores, cupellations, and refining, are true purifications of metallic matters. Amongſt all theſe operations, but a very few are called *purifications:* ſuch as the purification of ſilver by nitre, of gold by antimony; of both which we ſhall now treat.

DLXVIII. PURIFICATION *of* SILVER *by* NITRE. The ſilver to be purified by nitre is to be firſt granulated, and then mixed with a fourth part of its weight of dry nitre, an eighth part of potaſh, and a little common glaſs, all in powder. This mixture is to be put into a good crucible, two-thirds of which only muſt be full. This crucible is to be covered with a ſmaller crucible inverted, and luted to the former, and in the bottom of which a ſmall hole has been made. The crucibles thus diſpoſed are to be placed in a furnace, capable of drawing air ſufficiently to make the fire intenſe enough only to melt the ſilver. Then charcoal is to be put into the furnace to ſuch a height, that only the top of the inverted crucible ſhall be uncovered. The coal is then to be kindled, and the veſſels to be made moderately red: a hot coal ought to be put upon the ſmall hole in the bottom of the inverted crucible. If a ſhining light be obſerved round this coal, and a ſlight hiſſing noiſe be at the ſame time heard, we may know that the operation proceeds well. The fire muſt be ſuſtained at the ſame degree, till theſe appearances ceaſe; when it muſt be encreaſed ſo that the ſilver be well melted, and then the crucibles are to be taken out of the furnace. The larger crucible is to be broken when it is cold, and the ſilver will be found at the bottom covered with a green alkaline ſcoria. If the metal be not ſufficiently pure and ductile, the operation muſt be again repeated.

This operation is founded on a property which nitre has of effectually calcining all imperfect metals, by burning their phlogiſton; and alſo upon a property of calcined metals, by which they cannot be united with others in their metallic ſtate. This being eſtabliſhed, when ſilver allayed with copper or other imperfect metals is to be treated with nitre, this ſalt quickly calcines theſe imperfect metals by detonating with their inflammable principle; and they are no ſooner calcined, than they are rendered incapable of remaining united with the ſilver. Theſe metallic calxes being alſo ſpecifically lighter, riſe above the ſilver, where they meet the alkaliſed nitre and potaſh, with both which they form a ſcoria. The ſilver being capable of reſiſting the action of the nitre, is thus diſengaged from its allay, is fuſed, and collected at the bottom of the crucible.

As the purification of ſilver is effected by the detonation of nitre with the imperfect metals, and as this detonation is always accompanied with ſwelling and effervescence, the crucibles muſt not be too firmly cloſed, otherwiſe this effervescence might break them, and ſome of the contained matter might be loſt: therefore a ſmall hole is left in the upper crucible, which ſerves as a cover to the other; beſides, the empty ſpace left in the veſſels thus diſpoſed, allows the matter contained to ſwell a little without loſs.

This ſmall hole is alſo very uſeful to ſhew the proper degree of fire during the operation, as has been ſaid. The light and the hiſſing noiſe, which may be perceived when a coal is applied, are occaſioned by part of the nitre which is raiſed up undecompoſed during the detonation. When theſe effects are too conſiderable, and that a ſenſible hiſſing may be heard at the ſmall hole, even when a hot coal is not applied to it, we may know that the detonation is too violent. In that caſe the fire muſt be leſſened, otherwiſe much of the nitre would be carried off, and together with it, ſome part of the ſilver, which would be loſt. And even, notwithſtanding all the precautions that can be uſed, this operation can ſcarcely be performed without ſome loſs of the ſilver. Small grains of ſilver are always to be ſeen in the upper crucible, and about the ſmall hole in it. This inconvenience prevents the operation from being employed to determine the value of ſilver, for which purpoſe *cupellation* is therefore uſed.

The purification of ſilver by nitre, has neverthelefs its peculiar advantages in ſome circumſtances. It is more quick and expeditious than cupellation, and the loſs of ſilver is not conſiderable, when all the proper attentions are obſerved. *See* SILVER, NITRE, *and* DETONATION *of* NITRE.

DLXIX. PURIFICATION *of* GOLD *by* ANTIMONY.

To purify gold from its allays by antimony, the gold is to be melted in a crucible large enough to contain thrice the quantity of metal. When the gold is melted, twice its weight of crude antimony powdered is to be thrown upon it; the crucible is to be covered, and the matter left ſome minutes in fuſion: after which, when the mixture is well fuſed, and ſo hot that its ſurface ſparkles, it is quickly to be poured into an iron cone, previouſly heated and greaſed. By ſtriking the cone againſt the ground, the deſcent of the regulus will be aſſiſted; and when the cone is cold, it is to be inverted, and the matter taken out. This matter conſiſts of two ſubſtances; the upper one of which is compoſed of the ſulphur of the antimony united with the metals with which the gold was allayed, and the lower is the gold united with a quantity of the regulus of antimony proportionable to the quantity of metals which have been ſeparated from the gold, and which are now united with the ſulphur of the antimony. This regulus of gold may be ſeparated from the ſulphurated metals which cover it; and will be found to be ſo much leſs yellow, that is, mixed with ſo much more regulus of antimony, as the gold was more allayed.

As a ſingle fuſion is not generally ſufficient to diſengage the gold from all its allay, it ought to be fuſed again in the ſame manner, and with the ſame quantity of antimony, and even a third time, if the gold was much allayed. It is fuſible with leſs fire the ſecond and third time than the firſt, from the regulus of antimony which is united with it.

This first part of the purification of gold by antimony is founded on a property of sulphur, by which it is incapable of uniting with gold, and is strongly disposed to unite with all other metallic substances excepting platina and zinc; and also upon this property of sulphur, that it has less affinity with regulus of antimony than with any metallic substance with which it can unite. Hence when gold allayed with silver, copper, iron, lead, &c. is melted together with crude antimony, these latter metals unite with the sulphur of the antimony, while the reguline part, disengaged by them from its sulphur, unites with the gold. The separation of metals from gold is then really occasioned by the sulphur of the antimony. This purification of gold is consequently a kind of *dry parting*, but it succeeds better than the dry parting by sulphur alone. The reason of this difference is, that sulphur being very volatile and inflammable, is in great measure dissipated and consumed, when it is employed alone, before it can seize the metals allayed with the gold; whereas when it is already united with a metallic substance, as it is in the antimony with the reguline part, which prevents it from being quickly consumed and dissipated, it may be much more easily applied to the metallic substances allayed with gold. Notwithstanding this advantage, as a quantity of regulus of antimony is always united with the gold, proportionable to the quantity of metallic substances separated by means of the sulphur of the antimony; and as the separation of this regulus from the gold requires much time, as we shall soon see; therefore, when we would purify gold that is much allayed, suppose under 16 karats, we ought to add along with the antimony some pure sulphur, that we may have a less quantity of regulus to separate afterwards from the gold.

When these first fusions have been well made, the gold obtained is allayed with only regulus of antimony. But as this semi-metal is very volatile and very combustible, it may be separated from the gold by a sufficiently long exposure to the action of fire. For this purpose, the regulus of gold obtained by the former operation is to be put into a large crucible, and heated sufficiently to keep it in good fusion. With this heat, the antimony will be dissipated in smoke. If the heat be too strong, some of the gold will be carried off with the antimony. The operation therefore must be performed slowly; and it continues a long time, when much of the regulus of antimony is united with the gold; but it may be abridged by blowing on the surface of the metallic mass, because the application of fresh air accelerates the evaporation of all bodies, and particularly that of the regulus of antimony. When a part of the regulus is dissipated, more heat is required to keep the metal fused, and therefore the fire must be encreased towards the end of the operation: besides, when only a small quantity of regulus of antimony remains, it is so covered by the gold, and protected from the action of the fire and air, that a stronger heat is necessary to evaporate it. The smoke ceases entirely towards the end of the operation, although some regulus still remains united with the gold. The purification is compleated by means of a little nitre thrown into the crucible, which effectually calcines the remaining regulus of antimony. Sometimes after these operations, the gold is found to be deprived of much of its usual ductility, which however is easily restored to it by fusing it with nitre and borax.

The ancient chemists called antimony the *balneum regis*, or the *balneum solis*, and the *lupus metallorum*, from this property which it possesses, of purifying gold. The sulphur of this mineral does, indeed, seize almost all the metals with which gold can be allayed; but these metals are not destroyed, but only reduced to a sort of mineral state by the sulphur, forming the scoria, from which they may be obtained. Therefore, when the gold contained much allay of silver, the scoria is very valuable, since it contains all the silver which was united with the gold. This scoria ought to be preserved and treated like an ore of silver, and thus the metal extracted from it. *See* ESSAYS, *and* SMELTING *of* ORES. *See also* ANTIMONY, GOLD, SULPHUR.

DLXX. PUTREFACTION. Putrefaction is an intestine motion or fermentation excited in the proximate principles of vegetables and animals, by which a decomposition and total change of the nature of these principles are produced, and an alkaline quality is given to the saline principles of the compound bodies which suffer it.

As putrefaction is a true fermentation, and even is the termination and ultimate degree of all fermentations, therefore all vegetable and animal matters which are fermentable, are also capable of putrefaction. Some matters are susceptible of putrefaction only, and not of the two previous degrees of fermentation, namely, the spirituous and the acid fermentations. These matters have either already suffered the two previous degrees of fermentation, or their principles are disposed by nature in the same manner as if they had already suffered these fermentations: most substances perfectly animalised are of this kind.

When fermentable matters of this kind contain a sufficient quantity of water, when they are exposed to a suitable degree of heat, and have all the requisite conditions for fermentation in general, they never fail to suffer putrefaction. The phenomena accompanying this last degree of fermentation are nearly the same as those of the two former degrees, excepting that they are less sensible, at least when the putrefaction proceeds slowly. But this subject has not been sufficiently attended to. Mr. Beaumé affirms, that putrefaction is not accompanied with any sensible heat. When indeed the putrefaction proceeds slowly, and the quantity of putrefying matter is but small, the heat, if any, is very little; but the most sudden and remarkable changes produced upon a body by putrefaction, are upon its color, smell, and taste. Flesh beginning to putrefy is well known to exhale very soon a penetrating fetid smell, its color to become livid and black, and its taste nauseous. Transparent liquors, as urine and broth, during putrefaction, become also turbid. As the putrefaction advances, the smell becomes more and more fetid, but it also acquires great pungency. This pungent smell of putrefying matters is very sensible in houses of office, when the weather is changing, particularly before a frost. This pungency is sometimes so considerable that it excites coughing, and draws tears from the eyes. It is caused by a large quantity of volatile alkali, which is disengaged when these substances are completely putrified.

Solid bodies, while they are putrefying, swell, become soft, lose the cohesion of their parts, and are lastly reduced to a very disgustful liquor.

From

From matters completely putrefied may be obtained by diſtillation volatile alkali, ſome liquid and ſome ſolid; pungent, fetid oil, which at firſt is thin, and afterwards becomes more thick; and a reſiduum of coal not eaſily reducible to aſhes. Moſt chemiſts affirm that no fixed alkali is obtained from matters which have undergone a compleat putrefaction; but Mr. Beaumé aſſures us that theſe matters contain fixed alkali ready formed, which may be obtained without fire. This matter requires a more particular examination; perhaps ſeveral ſtages of putrefaction are attended with conſiderable differences in this reſpect.

From the hiſtory of putrefaction we may ſee that this laſt degree of fermentation alters entirely the nature of ſubſtances which ſuffer it, whatever the qualities of their proximate principles may be. By putrefaction they loſe their diſtinctive properties, as they are all converted into volatile alkali, fetid oil, and earth: their organization is deſtroyed, their veſſels, fibres, cells, the very texture of the moſt ſolid parts, are changed, disjoined, and entirely reſolved. All theſe changes are ſpontaneouſly produced upon organized bodies as ſoon as their vital motion ceaſes. As ſoon as vegetables and animals die, nature completes their deſtruction, decompoſes machines now uſeleſs, reduces their materials to a ſimilar and common ſtate; elaborates them again, ſo as to fit them to paſs into the organization of other beings, which alſo muſt afterwards undergo the ſame changes. Thus by an uninterrupted courſe of operations, nature inceſſantly renews the life of beings, which, notwithſtanding the old age and deaths of individuals, is ſuſtained in perpetual vigor and youth, as has been obſerved by one of our moſt eloquent modern philoſophers.

We have already remarked that the nature and phenomena of putrefaction have been but too little examined hitherto. We ſhall add here, that whatever attention may be given to this ſubject, we ſhall perhaps be never able to know more than the beginnings of this operation, and even a ſmall part only of theſe. In fact, putrefaction ſeems to be a very extenſive operation, and its laſt ſtage ſeems in ſome meaſure out of our reach. We conſider that a matter is entirely putrefied, when nothing remains but earth, or the fixed parts of it. But theſe coarſe materials are the leaſt part of thoſe which compoſe organiſed bodies. The exiſtence even of theſe reſiduums deprived of all other principles, the volatility of the ſaline and oily principles which are continually exhaling and diſſipating during putrefaction, ſhew that nature is inceſſantly, during this operation, attenuating, ſubtilizing, volatilizing, and carrying off all it can of theſe bodies; and all the ſubſtances, thus elaborated and carried off, are removed from the reach and obſervation of our ſenſes. We do not know, and probably we never ſhall know, what further changes they ſuffer, before they enter into the combination of new beings.

But if the compleat theory of putrefaction be very difficult, it is alſo very important, as it ſeems to be the true key of the moſt eſſential and hidden ſecrets of the animal economy. In fact, as the proper ſubſtance of all the parts of the bodies of animals differs from vegetable matters, (by which all animals are mediately or immediately nouriſhed) in this circumſtance, that they are much nearer the ſtate of putrefaction, we have reaſon to believe that the change of vegetable into animal matters is principally produced by a kind of fermentation, or even by a beginning, ſlow, and imperceptible putrefaction. In this

point, certainly, perfect *animalisation* consists; and consequently the animal economy cannot fail of being deranged, and reduced to a morbid state, whenever this animalisation, or imperceptible putrefaction, (for I do not scruple to give it that name) becomes too much or too little: which truth is well perceived by the great Boerhaave in his aphorisms concerning the diseases proceeding from spontaneous acids and alkalis.

These considerations are certainly sufficient to induce chemists and physicians to acquire all the knowledge they can on this subject. The first trials to be made in this way, and from which the greatest certainty and utility may be expected, are researches to shew what substances accelerate and retard putrefaction. Messrs. Pringle and Macbride have made the first steps, and have published the interesting experiments which they have made on this subject, which is very far from being exhausted. I know that a very able French experimental philosopher has finished a numerous set of well made experiments on this subject, which he proposes soon to publish. *See* FERMENTATION. (*b*)

(*b*) To the above article we make the following additions.

1. Putrefaction, as also fermentation in general, seem to consist not merely in the decomposition and transposition of the particles of the putrefying or fermenting matter, by which new combinations are produced, but also in the extrication and expulsion of some of the constituent parts of these matters. The constituent part, thus extricated and expelled by putrefaction and fermentation, is a permanently elastic vapor, or fixable air. A part of the air extracted from putrefying substances was found by Mr. Cavendish's experiments to be inflammable. *See* AIR, (FIXABLE). And from the experiments of Dr. Macbride, which shew that caustic alcali and quicklime may be rendered mild, or combined with air, by absorbing the elastic vapor extricated from putrefying and fermenting substances, we have reason to believe that another part of the vapor extricated from these substances is of the uninflammable kind of fixable air which combines with alkaline salts and earths. *See* AIR (FIXABLE) *and* QUICKLIME.

Dr. Hales believes that this air is the principal cause of cohesion and solidity of bodies. He remarks that air abounds much more in solid than in liquid bodies, and that solid bodies being generally denser than water, the attraction of the air of these solid bodies, in a fixed state, and its repulsion when in an elastic state, are greater than the attraction and repulsion of the lighter watery particles in a fixed and in an elastic state; and hence the particles of air are fitter to be the principal band of union in solid bodies, than the particles of water. That Sir Isaac Newton had entertained a similar opinion, appears from the following passage in the third book of his Optics. "The particles of fluids "which do not cohere too strongly, and are "of such a smallness as renders them most "susceptible of those agitations which keep "liquors in a fluor, are most easily sepa- "rated and rarefied into vapor, and, in the "language of the chemists, they are vola- "tile, rarefying with an easy heat, and con- "densing with cold. But those which are "grosser, and so, less susceptible of agi- "tation, or cohere by a stronger attraction, "are not separated without a stronger heat, "or perhaps not without fermentation. And "these last are the bodies which chemists "call *fixed*, and being rarified by fer- "mentation become true permanent air; "those particles receding from one another "with the greatest force, and being most "difficultly brought together, which upon "contact cohere most strongly. And because "the particles of permanent air are grosser, "and arise from denser substances than those "of vapors, thence it is that true air is "more ponderous than vapor, and that a "moist atmosphere is lighter than a dry "one, quantity for quantity."

Dr. Macbride also maintains this opinion, and further endeavors to shew, that without the extrication of this air, no putrefaction can happen, and even that by absorption of it, putrefied substances may be corrected and rendered sweet. Having exposed putrid matters to the vapors arising from ferment-

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DLXXI. PYRITES. Pyrites is a mineral resembling the true ores of metals, in the substances of which it is composed, in its color or lustre,

ing mixtures, or from alkaline substances effervescing with acids, he found the putrid quality was destroyed; and hence he considers this air as powerfully antiseptic.

2. Contact of atmospherical air is said to be necessary to putrefaction; and Mr. Boyle relates that he has preserved lemons, oranges, and other fruits, from putrefaction, or other fermentation, during several years, by including them in an inexhausted receiver. Dr. Macbride found that putrefaction was accelerated by enclosing a piece of flesh in an exhausted receiver; but that another piece continued sweet, which was included in an exhausted hollow brass sphere, consisting of two hemispheres joined together. He conjectures that the cause of this difference might be, that in the latter experiment the vacuum was more perfect than in the former, as the glass receiver did not seem to exclude with sufficient accuracy the external air, and that tho' a partial vacuum may accelerate putrefaction, yet some air may be necessary to this process.

It is well known that bodies are preserved from putrefaction by covering them with wax, suet, &c. Whether is this effect produced merely by excluding external air, or also by preventing the extrication of the internal fixable air?

3. Sir John Pringle has made experiments to determine the powers of certain substances to promote or to prevent putrefaction. From these experiments he has formed the following table, shewing the relative antiseptic powers of the saline substances mentioned. Having found that two drams of beef put in a phial with two ounces of water, and placed in a heat equal to 90 degrees of Fahrenheit's thermometer, became putrid in 14 hours, and that sixty grains of sea-salt preserved a similar mixture of beef and water more than 30 hours, he made the antiseptic power of the sea-salt a standard, to which he compared the powers of the other salts. The algebraic character + signifies that the substance to which it is annexed had a greater antiseptic power than is expressed by the numbers.

Sea-salt, or the standard	1
Sal-gem —	1 +
Vitriolated tartar	2
Spiritus Mindereri	2
Soluble tartar	2
Sal diureticus —	2 +
Crude sal ammoniac	3
Saline mixture —	3
Nitre —	4 +
Salt of hartshorn	4 +
Salt of wormwood	4 +
Borax —	12
Salt of amber	20
Alum —	30

N. B. The quantities of spiritus Mindereri and of the saline mixture were such, that each of them contained as much alkaline salt as the other neutral salts.

Myrrh, *aloes*, *assafetida*, and *terra Japonica*, were found to have an antiseptic power 30 times greater than the standard. *Gum ammoniacum*, and *sagapenum*, shewed little antiseptic power.

Of all resinous substances, *camphor* was found to resist putrefaction most powerfully. Sir John Pringle believes that its antiseptic power is 300 times greater than that of sea-salt.

Chamomile flowers, *Virginian snake-root*, *pepper*, *ginger*, *saffron*, *contrayerva root*, and *galls*, were found to be 12 times more antiseptic than sea-salt.

Infusions of large quantites of *mint*, *angelica*, *ground-ivy*, *green tea*, *red roses*, *common wormwood*, *mustard*, and *horse-radish*, and also decoctions of *poppy-heads*, were more antiseptic than sea-salt.

Decoctions of *wheat*, *barley*, and other *farinaceous grains*, checked the putrefaction by becoming sour.

Chalk, and other *absorbent powders*, accelerated the putrefaction, and resolved meat into a perfect mucus. The same powders prevented an infusion of farinaceous grains from becoming mucilaginous and sour.

One dram of *sea-salt* was found to preserve two drams of fresh beef in two ounces of water, above 30 hours, uncorrupted, in a heat equal to that of the human body, or above 20 hours longer than meat is preserved in water without salt; but half a dram of salt did not preserve it more than two hours longer than pure water. Twenty-five grains of

in its great weight, and, lastly, in the parts of the earth in which it is found, since it almost always accompanies ores. It is, like ores, composed of metallic substances, mineralised by sulphur or by arsenic, or by both these matters, and of an unmetallic earth intimately united with its other principles.

Notwithstanding the conformity of pyrites with ores properly so called, chemists and metallurgists distinguish the former from the latter minerals;

of salt had little or no antiseptic quality. Twenty grains, fifteen grains, but especially ten grains only of sea-salt were found to accelerate and heighten the putrefaction of two drams of flesh. These small quantities of sea-salt did also soften the flesh more than pure water.

The same ingenious physician made experiments to discover the effects of mixing vegetable with animal matters.

Two drams of raw-beef, as much bread, and an ounce of water, being beat to the consistence of pap, and exposed to 90° of heat, according to Fahrenheit's thermometer, began to ferment in a few hours, and continued in fermentation during two days. When it began to ferment and swell, the putrefaction had begun; and in a few hours afterwards, the smell was offensive. Next day the putrid smell ceased, and an acid taste and smell succeeded. Fresh alimentary vegetables, as spinnage, asparagus, scurvy-grass, produced similar effects as bread on flesh, but in a weaker degree. From several other experiments he found that animal substances excite the fermentation of vegetable substances, and that the latter substances correct the putrescency of the former.

By adding *saliva* to a similar mixture of flesh, bread, and water; the fermentation was retarded, moderated, but rendered of twice the usual duration, and the acid produced at last was weaker than when no saliva was used.

By adding an *oily substance* to the common mixture of flesh, bread and water, a stronger fermentation was produced, which could not be moderated by the quantity of saliva used in the former experiment, till some *fixed alkaline salt* was added, which salt was found, without saliva, to stop suddenly very high fermentations.

He did not find that *small quantities* of the following salts, *sal ammoniac*, *nitre*, *vitriolated tartar*, *sal diureticus*, *salt of hartshorn*, *salt of wormwood*, were septic, as small quantities of sea-salt were.

Sugar was found to resist putrefaction at first, as other salts do, and also to check the putrefaction after it had begun by its own fermentative quality, like bread and other fermentative vegetables.

Lime-water made some small resistance to putrefaction.

Port wine, *small-beer*, infusions of *bitter vegetables*, of *bark*, and the juice of *antiscorbutic plants*, retarded the fermentation of mixtures of flesh and bread. But an *unstrained decoction of bark* considerably encreased that fermentation.

Crabs-eyes accelerated and encreased the fermentation of a mixture of flesh and bread.

Lime water neither retarded nor hastened the fermentation of such a mixture: but when the fermentation ceased, the liquor was neither putrid nor acid, but smelt agreeably.

Flesh pounded in a mortar was found to ferment sooner than that which had not been bruised.

The tough inflammatory crust of *blood* was found to be most putrescent, next to which the crassamentum, or red coagulated mass, and lastly the serum.

Dr. Macbride's experiments confirm many of these above related, especially those which shew that the fermentation of vegetable substances is encreased by a mixture of animal or putrescent matter; that the putrescency of the latter is corrected by the fermentative quality of the former; and that the putrefaction and fermentation of mixtures of animal and vegetable substances were accelerated by additions of absorbent earths and of Peruvian bark: He also found that altho' unburnt calcareous earths were septic, quicklime and lime-water prevented putrefaction, but that they destroyed or dissolved the texture of flesh.

The experiments of the author of the *Essai pour servir a l'Histoire de la Putrefaction* shew that metallic salts, resinous powders, extracts of bark, and opium, are very powerfully antiseptic, and that salts with earthy bases are less antiseptic than any other salts.

and

and they do this with propriety, becaufe the proportion and connexion of the materials compofing the pyrites differ much from thofe of ores.

Altho' fometimes pyrites contains more metal than fome ores, yet generally it contains lefs metal, and a larger quantity of mineralifing fubftances, fulphur and arfenic, and particularly of unmetallic earth. The connexion of thefe matters is alfo much ftronger in pyrites than in ores, and they are accordingly much harder; fo that almoft every pyrites can ftrike fparks from fteel. From this property of ftriking fparks from fteel they have been called pyrites, which is a Greek word fignifying *fire ftone*. Pyrites was formerly ufed for fire-arms, as we now ufe flints; hence it was called *carabine-ftone*. It is ftill named by fome, *marcafite*. Perhaps no other kind of natural body has received fo many names. Perfons curious to know the other names lefs ufed than thofe we have mentioned, may find them in *Henckel's Pyritologia*. We think, with that celebrated chemift, that the fubject has been perplexed by this multiplicity of names; for before his great and excellent work, the notions concerning pyrites were very confufed and inaccurate.

Pyrites differs alfo from ores by its forms and pofitions in the earth. Altho' pyritous minerals generally precede, accompany, and follow veins of ores; they do not, properly fpeaking, themfelves form the oblong and continued maffes called veins, as ores do, but they form maffes fometimes greater and fometimes fmaller, but are always diftinct from each other. Large quantities of them are often found unaccompanied by ores. They are formed in clays, chalk, marles, marbles, plafters, alabafters, flates, fpars, quartz, granites, cryftals, in a word, in all earths and ftones. Many of them are alfo found in pit-coals and in other bituminous matters.

Pyrites is alfo diftinguifhable from ores by its luftre and figure, which is almoft always regular and uniform, externally or internally, or both. Some ores indeed, like thofe of lead, many ores of filver, and fome others, have regular forms, and are in fome manner cryftallized; but this regularity of form is not fo univerfal, and fo confpicuous in ores as in pyrites. The luftre of pyrites feems to be caufed by its hardnefs, and the regularity of its form by the quantity of mineralifing fubftances which it contains.

By all thefe marks we may eafily, and without analyfis, diftinguifh pyrites from true ores. When we fee a mineral that is heavy, poffeffed of metallic luftre, and of any regular form, the mafs of which appears evidently to be entire, that is, not to have been a fragment of another mafs, and which is fo hard as to be capable of ftriking fparks from fteel, we may be affured that fuch a mineral is a pyrites, and not an ore.

The clafs of pyrites is very numerous, various, and extenfive. They differ one from another in the nature and proportions of their component parts, in their forms and in their colors. The forms of thefe minerals are exceedingly various. No folid regular or irregular can eafily be conceived that is not perfectly imitated by fome kind of pyrites. They are fpherical, oval, cylindrical, pyramidal, prifmatical, cubic; they are folids with 5, 6, 7, 8, 9, 10, &c. fides. The furface of fome is angular, and confifts of many bafes of fmall pyramids; while their fubftance is compofed of thefe pyramids, the points of which all unite in the center of the mafs.

Pyritous minerals differ alfo in their component fubftances. Some of them are called fulphureous, martial, cupreous, arfenical, as one or other of thefe fubftances

 predominate.

predominate. We must observe with Henckel, whose authority is very great in this subject, that in general all pyrites are martial, as ferruginous earth is the essential and fundamental part of every pyrites. This earth is united with an unmetallic earth, with sulphur or arsenic, or with both these matters; in which case, the sulphur always predominates over the arsenic, as Henckel observes. He considers these as the only essential principles of pyrites, and believes that all the other matters, metallic or unmetallic, which are found in it, are only accidental; amongst which he even includes copper, although so much of it exists in some kinds of pyrites, that these are treated as ores of copper, and sometimes contain even 50lb. of copper each quintal. Many other metals, even gold and silver, are sometimes combined in pyrites; but these are less frequent, and the precious metals always in very small quantities; they are therefore justly to be considered as accidental to pyrites. The different substances composing pyrites sensibly affect its colors. Henckel distinguishes them in general into three colors, white, yellowish or a pale yellow, and yellow. He informs us, that these three colors are often so blended one with another, that they cannot be easily distinguished, unless when compared together.

The white pyrites contain most arsenic, and are similar to cobalt and other minerals abounding in arsenic. The Germans call them *mispickel* or *mispilt*. Iron and arsenic form the greatest part of this pyrites. As arsenic has the property of whitening copper, some pyritous minerals almost white, like that of Chemnitz, in Misnia, are found to contain forty pounds of copper per quintal, and which are so much whitened by the arsenic, that they are very like white pyrites. But Henckel observes, that these pyritous matters are very rare, and are never so white as the true white pyrites, which is only ferruginous and arsenical.

Yellowish pyrites is chiefly composed of sulphur and iron. Very little copper and arsenic are mixed with any pyrites of this color, and most of them contain none of these two metallic substances. This is the most common kind of pyrites: it is to be found almost every where. Its forms are chiefly round, spherical, oval, flattened, cylindrical, and it is composed internally of needles or radii, which unite in the center or in the axis of the solid.

Yellow pyrites receives its color from the copper and sulphur which enter into its composition. Its color, however, is inclined to a green, but is sufficiently yellow to distinguish it from the other two kinds of pyrites, particularly when they are compared together. To make this comparison well, the pyrites must be broken, and the internal surfaces must be placed near each other. The reason of this precaution is, that the color of minerals is altered by exposure to the air.

Persons accustomed to these minerals can easily distinguish them. The chief difficulty is to distinguish white pyrites from cobalt and other minerals, which also contain some copper and much arsenic.

Hence then we see, that arsenic is the cause of whiteness in pyrites, and is contained in every pyrites of that color; that copper is the principal cause of the yellow color of pyrites; and that every pyrites which is evidently yellow contains copper; that sulphur and iron produce a pale-yellow color, which is also produced by copper and arsenic; hence some difficulty may arise in distinguishing

guiſhing pyrites by its colors. We may alſo obſerve, that ſulphur and arſenic, without any other ſubſtance, form a yellow compound, as we ſee from the example of orpiment or yellow arſenic. Thus, although the colors of the pyrites enable us to diſtinguiſh its different kinds, and to know their nature at firſt ſight, particularly when we have been accuſtomed to obſerve them; yet we cannot be entirely certain concerning the true nature of theſe minerals, and even of all minerals in general, that is, to know preciſely the kinds and proportions of their component ſubſtances, but by chemical analyſis and decompoſition.

Beſides the above-mentioned matters which compoſe pyrites, it alſo contains a conſiderable quantity of unmetallic earth, that is, an earth which cannot by any proceſs be reduced to metal. Henckel, Cramer, and all thoſe who have examined this matter, mention this earth, and prove its exiſtence.

We ought to obſerve, that this earth is combined with the other principles of the pyrites, and not merely interpoſed betwixt its parts. It muſt therefore be diſtinguiſhed from other earthy and ſtony matters mixed accidentally with pyrites, and which do not make a part of the pyrites, ſince they may be ſeparated by mechanical means, and without decompoſing that mineral: but the earth of which we now treat is intimately united with the other conſtituent parts of the pyrites, is even a conſtituent part of pyrites, and eſſential to the exiſtence of this mineral, and cannot be ſeparated but by a total decompoſition of it.

According to Henckel, this unmetallic earth abounds much in the white pyrites, ſince he found from the analyſes which he made, that the iron, which is the only metal exiſting in theſe pyrites, is only about $\frac{1}{20}$th part of the fixed ſubſtance that remains after the arſenic has been expelled by torrefaction or ſublimation.

A much larger quantity of iron is in the pale-yellow pyrites, according to Henckel. The proportion of iron is generally about twelve pounds to a quintal of pyrites, and ſometimes fifty or ſixty pounds: this is therefore called martial pyrites. It contains about $\frac{1}{4}$ of its weight of ſulphur, and the reſt is unmetallic earth.

The quantity of unmetallic earth contained in the yellow or cupreous pyrites, which are alſo martial, ſince, as we have obſerved, iron is an eſſential part of every pyrites, has not yet been determined. They probably contain ſome of that earth, though perhaps leſs of it than the others.

The nature of this unmetallic earth of pyrites has not been well examined. Henckel thinks that it is an earth diſpoſed already by nature to metallization, but not ſufficiently elaborated to be conſidered as a metallic earth. *See the articles* METALS *and* METALLISATION. This opinion is not improbable; but as alum may be obtained from many pyrites, may we not ſuſpect that this unmetallic earth is of the nature of the baſis of alum or argillaceous earth? *See* ALUM *and* CLAY. Perhaps alſo this earth is different in different kinds of pyrites. The ſubject deſerves to be well examined.

Although pyrites is not ſo valuable as true ores, becauſe in general it contains leſs metal, and but exceedingly little of the precious metals; and becauſe its metallic contents are ſo difficult to be extracted, that, excepting cupreous pyrites, which is called *pyritous copper ore*, it is not worked for the ſake of the

 contained

contained metal; yet it is applied to other purpoſes, and furniſhes us with many uſeful ſubſtances; for from it we obtain all our green and blue vitriols, much ſulphur, arſenic, alum, and orpiment. *See the principal proceſſes by which theſe ſubſtances are extracted from pyrites, under the article* SMELTING *of* ORES.

As every pyrites contains iron, and moſt of them contain alſo ſulphur; as the pyrites moſt frequently found contains only theſe two ſubſtances with the unmetallic earth; and as iron and ſulphur have a ſingular action upon each other, when they are well mixed together and moiſtened; hence many kinds of pyrites, particularly thoſe which contain only the principles now mentioned, ſuſtain a ſingular alteration, and even a total decompoſition, when expoſed during a certain time to the combined action of air and water. The moiſture gradually penetrates them, divides and attenuates their parts; the acid of the ſulphur particularly attacks the martial earth, and alſo the unmetallic earth, its inflammable principle is ſeparated from it, and is diſſipated. While theſe alterations happen, the pyrites changes its nature. The acid of the ſulphur which is decompoſed forms with the fixed principles of the pyrites, vitriolic, aluminous, and ſelenitic ſalts; ſo that a pyrites which was once a ſhining, compact, very hard mineral, becomes in a certain time a greyiſh, ſaline, powdery maſs, the taſte of which is ſaline, auſtere, and ſtiptic.

Laſtly, if this maſs be lixiviated with water, cryſtals of vitriol, and ſometimes of alum, according to the nature of the pyrites employed, may be obtained by evaporation and cryſtallization.

This alteration and ſpontaneous decompoſition of pyrites is called *effloreſcence* and *vitrioliſation*; becauſe the pyrites becomes covered with a ſaline powder; and becauſe vitriol is always formed. This vitrioliſation is more or leſs quickly accompliſhed in pyrites according to its nature. It is a kind of fermentation excited by moiſture amongſt the conſtituent parts of theſe minerals; and it is ſo violent in thoſe which are moſt diſpoſed to it, that is, in the pale-yellow pyrites, which contain chiefly ſulphur and iron, that when the quantity of theſe is conſiderable, not only a ſulphureous vapor and heat may be perceived, but alſo the whole kindles and burns intenſely. The ſame phenomena are obſervable, and the ſame reſults are formed, by mixing well together and moiſtening a large quantity of filings of iron and powdered ſulphur: which experiment Lemeri has made, to explain the cauſes of ſubterranean fires and volcanos.

We cannot doubt that, as the earth contains very large maſſes of pyrites of this kind, they muſt undergo the ſame changes when air and moiſture penetrate the cavities containing them; and the beſt natural philoſophers agree, that very probably this ſurprizing decompoſition of pyrites is the cauſe of ſubterranean fires, of volcanos, and of mineral waters, vitriolic, aluminous, ſulphureous, hot and cold.

No other pyrites is ſubject to this ſpontaneous decompoſition, when expoſed to humid air, but that which is both martial and ſulphureous, that is, the pale yellow pyrites. The arſenical pyrites, or that which contains little or no ſulphur, is not changed by expoſure to air. This latter kind is harder, heavier, and more compact than the former. The pyrites which is angular and regularly

regularly ſhaped, is chiefly of this kind. Mr. Wallerius, in his Mineralogy, propoſes to diſtinguiſh this kind of pyrites by the name of *marcaſite.* When cut, it may be poliſhed ſo well as to give a luſtre almoſt equal to that of diamonds, but without refracting or decompoſing the light; for it is perfectly opake. It has been employed ſome years paſt in the manufacture of toys, as of buckles, necklaces, &c and is called in commerce *marcaſite.* *See* WATERS (MINERAL), ORES, SMELTING *of* ORES. *(i)*

DLXXII. PYROPHORUS *of* HOMBERG. The Pyrophorus is a chemical preparation, which has the ſingular property of kindling ſpontaneouſly when expoſed to air. It was accidentally diſcovered by Mr. Homberg. This chemiſt was endeavouring to extract a limpid and flavorleſs oil from human ordure, which ſhould have the property of fixing mercury (*ſee* EXCREMENTS *of* ANIMALS); and when he had mixed the ſubſtance upon which he was operating with different matters, he was much ſurprized, while he was taking the caput mortuum of one of theſe mixtures out of a retort, four or five days after it had been operated upon, to ſee it kindle and burn ſtrongly as ſoon as it was expoſed to air. He recollected that this was the reſiduum of a mixture of alum and human feces from which he had obtained all that he could by means of a red-heat. He repeated the proceſs, and obtained from it the ſame reſult. When he was well aſſured of it, he publiſhed his diſcovery. Human feces were a long time believed to be eſſential to the operation, till the youngeſt ſon of the great Lemeri found, that honey, ſugar, flour, in a word, any animal or vegetable matter, might be ſubſtituted in place of the human feces; and ſince that time, Mr. Lejay de Suvigny, Doctor of Phyſic, a perſon well verſed in mathematical and phyſical ſciences, has communicated to the Academy a Memoir, relating experiments made on the pyrophorus, in which he generaliſes the proceſs, and gives the true theory of it. He there ſhews, that moſt vitriolic ſalts may be ſubſtituted for the alum; which diſcovery aſſiſted him greatly in explaining the theory of the operation. This Memoir is printed in the third volume of the Collection of Memoirs by correſpondents of the Academy.

(i) I do not know any ſufficient reaſon for conſidering the minerals called *pyrites* as a diſtinct claſs of ſubſtances from ores. They have indeed no mark by which they can certainly and conſtantly be diſtinguiſhed from theſe. The hardneſs or property of ſtriking ignited ſparks from ſteel is not common to all the ſubſtances generally called pyrites; for we find ſome of theſe enumerated by mineralogiſts which have not that property. Wallerius even mentions a pyrites which contains no iron, although that metal is thought by Henckel to be eſſential to pyrites. The diſtinction of pyrites from ores has been chiefly introduced by miners; becauſe the greateſt part of the former minerals contain ſo little metal, and ſo much of the mineraliſing ſubſtances, ſulphur, or arſenic, that they are ſeldom ſmelted. Nevertheleſs, ſome kinds of pyrites are found which contain ſo much copper, that they are ſmelted with great profit. Accordingly, ſome later mineralogiſts conſider the cupreous yellow pyrites as an ore of copper, the pale-yellow martial pyrites as an ore of iron, and the white arſenical pyrites as an ore of arſenic. *See* ORES *of* COPPER, IRON, *and of* ARSENIC.

Although alum is not abſolutely neceſſary for the preparation of the pyrophorus, yet it is one of the vitriolic ſalts which ſucceeds beſt. The following proceſs is very good for this preparation.

Let three parts of alum and one part of ſugar be mixed together. This mixture muſt be dried in an iron ſhovel over a moderate fire, till it be almoſt reduced to a blackiſh powder of coal, during which it muſt be ſtirred with an iron ſpatula. Any large maſſes muſt be bruiſed into powder, and then it muſt be put in a glaſs matraſs, the mouth of which is rather ſtrait than wide, and ſeven or eight inches long. This matraſs is to be placed in a crucible, or other earthen veſſel, large enough to contain the belly of the matraſs, with about a ſpace equal to the thickneſs of a finger all round it. This ſpace is to be filled with ſand, ſo that the matraſs ſhall not touch the earthen veſſel: the apparatus is then to be put in a furnace, and the whole to be made red-hot: the fire muſt be gradually applied, that any oily or fuliginous matter may be expelled. After which, when the matraſs is made red-hot, ſulphureous vapors exhale: This degree of heat is to be continued till a truly ſulphureous flame, which appears at the end of the operation, has continued nearly a quarter of an hour: the fire is then to be extinguiſhed, and the matraſs to cool without taking it out of the crucible; and when it ceaſes to be red-hot, it muſt be ſtopped with a cork. Before the matraſs is perfectly cold, it muſt be taken out of the crucible, and the powder it contains muſt be poured into a very dry glaſs phial, which muſt be well cloſed with a glaſs ſtopper. If we would preſerve this pyrophorus a long time, the bottle containing it muſt be opened as ſeldom as is poſſible. Sometimes it kindles while it is poured into the glaſs phial, but it may be then extinguiſhed by cloſing the phial expeditiouſly.

When half a dram of this pyrophorus is put on a piece of paper and expoſed to air, it quickly kindles, becomes red like burning coals, emits a ſtrongly ſulphureous vapor, and burns the paper or other combuſtible body which ſupports it.

This preparation has hitherto been uſed only to entertain curious perſons with a ſight truly ſurprizing, of a ſubſtance which contains within itſelf a principle of fire capable of burning ſpontaneouſly, and which being more inflammable than any other ſubſtance known, kindles without contact of an ignited matter. The phenomena which it exhibits confirm Stahl's theory concerning the compoſition of ſulphur, and give a ſtriking proof of the almoſt incredible force and activity with which the vitriolic acid, when highly concentrated, but not perfectly combined, unites with the moiſture of the air.

In the firſt place, we cannot doubt that ſulphur is formed in the operation of the pyrophorus; for the experiments made by Stahl demonſtrate, that the vitriolic acid engaged in any baſis quits that baſis, and unites with the inflammable principle whenever the circumſtances neceſſary for that union concur; as they all do in this caſe; and therefore ſulphur muſt be really formed. Beſides, although we had not this proof of it, the ſulphureous flame ſeen above the matraſs in which the pyrophorus is made, the peculiar ſmell of ſulphur which the pyrophorus when burning exhales, and, laſtly, the poſſibility of obtaining ſulphur ready formed, would ſufficiently demonſtrate this truth. *See* SULPHUR.

In the second place, probably the whole vitriolic acid of the alum is not employed to form fulphur in the operation of the pyrophorus; not becaufe a fufficient quantity of inflammable principle is not contained in the vegetable or animal matter with which it is mixed; but rather becaufe a fufficient time is not given for that purpofe, as we fhall prefently fee.

Thefe preliminary remarks being made, we obferve, that probably the portion of vitriolic acid of the alum, which has not had time to form perfect fulphur, being partly difengaged from the earth by the action of fire, and by the prefence of the inflammable principle; and being alfo greatly dephlegmated, fince it is in a dry ftate; is capable of uniting with the moifture of the air as foon as it is expofed to it; and with fuch activity, that a heat is produced fufficient to kindle the fulphur and a very combuftible fuliginous matter which are contained in the pyrophorus. This is the explanation given by Mr. Lejay de Suvigny; and is confirmed by the following obfervations.

Firft, the pyrophorus can be made only with fubftances fit for producing fulphur, or with fulphur itfelf, as Mr. de Suvigny has fhewn.

Secondly, no pyrophorus will be produced, if the mixture be calcined by too long or too violent a fire; becaufe then the whole vitriolic acid can be combined into perfect fulphur, and confequently is engaged, and not in a proper ftate to attract the moifture of the air; or elfe if it does not combine into fulphur, it being half difengaged from its bafis, is driven off by the violence or long continuance of the fire; and, confequently, after this compleat calcination, no acid remains partly difengaged, as it ought to be, that it might unite with the water with fufficient activity.

Thirdly, when the pyrophorus is very flowly moiftened, as when it is kept in a bottle not well clofed, it does not kindle, becaufe fufficient heat is not produced by this flow and gradual attraction of water. It is alfo fpoiled and rendered incapable of kindling, when expofed to the open air; becaufe its acid becomes then faturated or nearly faturated with moifture, and cannot therefore unite with that of the air with fufficient activity.

Fourthly, a pyrophorus thus fpoiled by expofure to moifture may be reftored to its peculiar properties by making it again red-hot in a matrafs; fince by this calcination its partly difengaged acid is again concentrated, and refumes all its force of combining with water.

Fifthly, the inflammation of the pyrophorus is accelerated by placing it upon paper a little wetted, or by breathing upon it; becaufe the acid then attracts the moifture more haftily, and confequently with more heat.

All thefe facts clearly prove, that the pyrophorus is inflamed by the extreme heat excited in its parts, from the fingular force and activity with which it feizes mofture. But further, as Mr. de Suvigny well remarks, the pyrophorus can only contain the bafis of the vitriolic falt employed, the earth of the vegetable or animal fubftance which furnifhed the inflammable matter, a coal, fome perfect fulphur, and fome imperfectly formed fulphur or vitriolic acid, which is but imperfectly engaged either by its bafis or by phlogifton. Now of all thefe fubftances, the acid only, which is alfo very concentrated, can attract moifture fo forcibly as to produce great heat. To this portion then of

vitriolic

vitriolic acid we muſt attribute the ſpontaneous inflammation of the pyrophorus. *See* ACID (VITRIOLIC), PHLOGISTON, *and* SULPHUR.

DLXXIII. PYROTECHNICKS. This Greek name, ſignifying the *art of fire*, has been given to chemiſtry, becauſe moſt chemical operations are made by fire: but it is now confined to the art of compoſing fireworks. *See* POWDER (GUN).

Q.

DLXXIV. QUARTATION. Quartation is an operation by which the quantity of one thing is made equal to a fourth part of the quantity of another thing. Thus when gold allayed with ſilver is to be parted, we are obliged to facilitate the action of the aqua fortis by reducing the quantity of the former of theſe metals to one fourth part of the whole maſs; which is done by ſufficiently encreaſing the quantity of the ſilver, if it be neceſſary. This operation is called quartation, and is preparatory to the parting; and even many authors extend this name to the operation of parting. *See* PARTING.

DLXXV. QUARTZ. Quartz is a hard vitrifiable ſtone, ſomething intermediate betwixt rock-cryſtals and flints, or opake vitrifiable ſtones. Quartz is a ſtone well known by metallurgiſts, mineralogiſts, and miners, as it is frequently and abundantly found with ores, of which it often forms the matrix. It is alſo frequently found where no ores are.

The moſt common quartz is more or leſs of a milky-white color, and conſequently ſemi-tranſparent. Some of them have various colors. This ſtone, which is very hard and very compact, is nevertheleſs cracked throughout its ſubſtance; to which alſo the rock-cryſtal is very liable, but much leſs ſo than quartz. The fragments of quartz are always angular, and its internal ſurface has but little gloſs. Quartz is a little waved, and has a greaſy appearance. It is found not only of various colors but alſo of various forms. It is frequently found cryſtallized in caverns and ſlits of rocks. Its cryſtallization is the ſame as that of rock-cryſtal. Quartz may be employed in vitrification, as all other vitrifiable ſtones are. *See* EARTHS (VITRIFIABLE) *for the nature and properties of quartz; and alſo the mineralogy of Wallerius, and the Dictionnaire d'Hiſtoire Naturelle de M. Bomare, for the different kinds of it.*

(*k*) Quartz is a ſtone of the kind called by authors *ſiliceous* or *vitrifiable*. Some of theſe ſtones conſiſt of impalpable particles, others have a granulated texture, and laſtly ſome have a ſparry or laminated texture. When pure, they are white and opake, or

DLXXVI. QUICKLIME. This name is given to all the earths and ſtones which have acquired, by expoſure to a certain heat, the following properties. [*Concerning the properties of theſe earths before calcination, ſee the article* EARTH (CALCAREOUS)].

Theſe ſtones by calcination loſe half of their former weight, and much of their hardneſs. This alteration ſhews that the calcareous ſtones, before calcination, are not a pure earth, but a compound of a fixed earthy matter and of ſome volatile ſubſtance, of which they may be deprived by fire.

After the calcination has been completed, and the ſtones are become cold, if water be applied to them, it penetrates them with conſiderable heat and violence, divides and ſeparates their parts, and reduces them to a very fine paſte, if the quantity of water added has not been too great. The paſte of quicklime thus ſlaked ſtrongly retains the water, and when mixed with ſand or with pounded baked clay, it becomes very hard in a certain time. This mixture is called *mortar*.

The water employed to ſlake the quicklime diſſolves a part of it, and is called *lime water*. When this water is expoſed to evaporation, a ſemi-cryſtalline pellicle is formed on its ſurface, which is the diſſolved quicklime: this pellicle ſoon falls to the bottom, and another is formed on the ſurface, till almoſt all the earthy matter once diſſolved be ſeparated from the water. Lime-water has a ſharp, urinous taſte, which the calcareous earth had not before calcination.

The ſlaked lime by another calcination is reduced to the ſtate of quicklime, as it was before.

Quicklime combines with the moiſture of the air which it ſeems capable of attracting. By the moiſture thus attracted, the weight of the quicklime is doubled, its bulk is alſo encreaſed, its parts are very much divided, and it is reduced to an exceeding fine powder. In this ſtate it is called *lime ſlaked in the air*.

Lime ſlaked in the air may be reduced, by another calcination, to its former ſtate of quicklime, in the ſame manner as lime ſlaked by water.

Quicklime is capable of uniting with certain ſubſtances, (as, for inſtance, with ſulphur, with which it forms an *earthy liver of ſulphur*) to which the uncalcined calcareous earth could not unite ſo intimately.

they are colorleſs and tranſparent. When mixed with calxes of iron or of copper, they are black or red. This ſtone does not decay in the air, as ſome other ſiliceous ſtones do. According to Cronſtedt, it always forms hexagonal priſms, pointed at one or both ends, when there has been no interruption to its cryſtallization; and this cryſtallized quartz is rock-cryſtal, which, like the uncryſtallized quartz, is colorleſs or colored, tranſparent or opake. *See* CRYSTAL.

Wallerius ſays, that every quartz is fuſible by fire: but probably the quartz colored by metallic calxes are only fuſible; for Mr. D'Arcet found that the tranſparent and ſemi-tranſparent quartz, and alſo the opake white quartz, were rendered friable, but were not fuſed by a very violent and long continued fire; and that by the ſame fire the form and tranſparency of rock-cryſtals were not altered. *Memoir ſur l'Action d'un Feu Violent, Egal, & Continué, &c. Mem. de l'Acad. des Sc.* 1766.

Beecher and Hiærne ſay, that from quartz a ſmall quantity of alkali may be obtained by diſtillation or by frequent extinction of the heated ſtone in water. A ſimilar alkaline matter is ſaid to be obtainable by diſtillation from flints.

An important queſtion deſerves to be examined, concerning the nature of the volatile ſubſtance of which calcareous ſtones are deprived by fire, and whether the ſeparation of this volatile matter is the cauſe of the phenomena produced by quicklime.

As the properties of quicklime reſemble much thoſe of ſaline ſubſtances, and as even a kind of ſaline matter is obtained from it, moſt chemiſts have believed, that all calcareous ſtones contain more or leſs of ſome ſalt; which being mixed with an earthy matter, cannot ſhew its properties till it has been partly unfolded and diſengaged by the action of fire. Their opinion is grounded on ſome ſaline matter obtained from calcareous ſtones by diſtillation with a violent fire, or from quicklime after its calcination.

Van Helmont, and after him Daniel Ludovicus, pretend to have made an experiment from which they have inferred a peculiar opinion. Theſe chemiſts, having expoſed lime-ſtone to a violent fire in a retort, obtained only a pure water; and they affirm, that the remaining ſtone was not by this operation converted into quicklime. This experiment, together with ſome marks which may be perceived of inflammable matter being contained in lime-ſtone, has induced them to believe, that this inflammable matter is ſo intimately united with the ſaline part of the lime-ſtone, that this cannot exert its properties; and that this matter being, like coals, incapable of combuſtion in cloſe veſſels, it cannot diſengage the ſaline part, that is, quicklime cannot be made, but by calcination in open fire.

Mr. Macquer has repeated this experiment, as may be ſeen in his Memoir upon Quicklime, (Memoirs of the Academy of Sciences, 1747) and found it to be only true in part.

This chemiſt, having expoſed lime-ſtones in a retort to a violent fire continued during ſix hours, obtained a purely aqueous liquor, which ſhewed no ſaline property, and obſerved that the remaining ſtone, though not entirely converted into quicklime, had nevertheleſs acquired all the properties of quicklime in a great degree. The calcination was therefore found to ſucceed in cloſe veſſels without the combuſtion of any inflammable matter contained in the ſtone. *See* CALCINATION.

We are certain therefore, that the experiment of Van Helmont and of Ludovicus proves nothing in favor of their opinion

Stahl believes, with more probability, that all the properties of quicklime proceed merely from ſuch a diviſion and disjunction of the integrant parts of the calcinable earth, by means of the calcination, that they are rendered capable of uniting with the particles of water. He believes that this union is already begun in lime-ſtone; that the fire, during the calcination, does only ſeparate the principles of this compound body, that is, expels the watery part, which being volatile, is incapable of reſiſting the action of fire, and ſeparates it from the earthy principle, and does not deprive the latter principle of its diſpoſition to unite with the former, but rather encreaſes this diſpoſition by attenuating the earthy matter. This theory explains in a ſatisfactory manner all the phenomena of quicklime.

All the properties of calcareous ſtones by which they differ from vitreſcible ſtones, that is to ſay, their inferior degrees of hardneſs and of weight, and the

loſs of matter which they ſuſtain by violent fire [*See* EARTH (CALCAREOUS), *and* EARTH (VITRIFIABLE)] ſhew, that they contain a principle leſs hard, leſs weighty, and leſs fixed than pure earth: but theſe are preciſely the eſſential properties which conſtitute the difference betwixt earth and water.

In fact, the experiments of Van Helmont, Ludovicus, and of Mr. Macquer ſhew, that water is the principle ſeparated from lime-ſtone during its calcination.

The difficulty with which fire expels all the watery part of lime-ſtone ſhews, that in this ſtone there is at leaſt ſome degree of the union of compoſition, and a true adheſion betwixt the integrant parts of water and thoſe of earth, and alſo gives an inſtance of the great degree of fire which water is capable of ſuſtaining when it is retained by means of an union contracted with a fixed matter. The degree of heat ſuſtained by water on this occaſion muſt neceſſarily enable the water to ſeparate more and more the integrant parts of the earthy matter, and to break their aggregation (in the Digeſtor of Papin), and to give it conſequently a greater diſpoſition to re-unite with water.

This being eſtabliſhed, if we add to quicklime the watery principle which the violence of the fire has expelled, the earthy particles having acquired by calcination a ſtrong diſpoſition to unite with water, theſe two ſubſtances will accordingly unite together with great activity; and as the primary molecules of the two uniting ſubſtances are very hard, the friction occaſioned by their motion during their union muſt produce a conſiderable heat.

This new union contracted by the parts of quicklime with water is much more perfect and more intimate than the union of the conſtituent parts of the lime-ſtone before calcination. As water and earth are the two elements of ſaline ſubſtances (*ſee* SALT), a new, at leaſt, a beginning combination muſt be formed by the extinction of quicklime. In conſequence of this combination, a taſte is given to lime-water, and *cream of lime* is produced, which is ſoluble in water, and ſeparable from thence like a true ſalt, and which muſt be conſidered as a ſaline matter, begun at leaſt, and overcharged with the earthy principle.

It appears certain that the cream of lime is not produced by any ſalts originally mixed with the lime-ſtone, unfolded by the action of fire, and thereby reſtored to their properties and ſolubility in water; for it is not credible that at leaſt the greateſt part of the ſaline matter, which may have been originally mixed with the calcareous earth of lime-ſtones, ſhould not have been already waſhed away by the water to which theſe ſtones have been often expoſed ſince their formation. Beſides, ſuppoſing even that ſome of that ſaline matter ſhould have remained, certainly it would be all waſhed out by one calcination of lime-ſtone, and extinction in water: but we know that quicklime once extinguiſhed, and boiled in any quantity of water, may, by another calcination, be reſtored to the ſtate of quicklime, and to the property of ſolubility in water, and of producing cream of lime as much as before. This phenomenon affords an additional proof, as well as an explanation of the theory of Stahl.

Further, the addition of any ſaline ſubſtances to lime-ſtones, which when calcined yield but a weak quicklime, not only does not render the quicklime more ſtrong and active, but, on the contrary, conſiderably injures its quality.

These facts have been advanced by Mr. Macquer, in his Memoir upon Quicklime, and they show that the properties of calcareous stones acquired by calcination are not occasioned by the presence of any saline matter

The firm adhesion of the water to slaked quicklime deserves attention, and is so considerable, that the water cannot be entirely separated but by a fire as violent as is required for the first calcination of lime-stone.

Mr. Duhamel has made a decisive experiment to shew the strength of this adhesion.

Having weighed an ounce of slaked quicklime, which had previously undergone several strong calcinations to deprive it of all its water; and observing that each ounce of this quicklime, notwithstanding all these calcinations, retained more than three gros and thirty-eight grains of water, he exposed it again to a very violent fire in a melting furnace, and found that notwithstanding this further calcination, his ounce of quicklime still retained twenty grains of moisture. (*Mem. of the Acad. of Sc.* 1747).

This retention of the water united to quicklime during its extinction may be naturally deduced from the adhesion contracted between earth and water; which two substances really form a new compound consisting of two principles, one of which is fixed, and the other is volatile, and in which the volatile part is retained by the fixed part with a strength proportionable to the perfection of the combination of these two substances. Hence we may explain the cause of the difficulty of drying slaked lime, and of the several phenomena before related which happened upon exposure of quicklime to air, and also of several other properties hereafter to be mentioned, all which shew the saline quality of this substance. It unites to all acids with the same phenomena, as it does before calcination: and the neutral salts with earthy bases, which are formed by the calcareous earth in these two states, are very similar to each other. [*See* SALTS (NEUTRAL) *with* EARTHY BASES].

Neverthless it seems as if the acid of all those salts, the basis of which is quicklime, adheres more strongly than the acid of salts, the basis of which is uncalcined calcareous earth.

Lime-water, which keeps dissolved the most attenuated and most saline portion of the quicklime, as we have already shewn, decomposes all salts with metallic bases.

Lastly, quicklime produces alterations upon fixed and volatile alkalis, which cannot be effected by uncalcined calcareous earths.

Fixed alkalis, treated with quicklime, become much more difficult to be dried, more deliquescent, more caustic, and much more powerfully solvent. The same alterations are produced by means of quicklime upon volatile alkali, which is thereby rendered much more penetrating, and so strongly deliquescent that it cannot be then obtained in a concrete state.

These changes are probably produced by the quicklime depriving the alkalis of some inflammable matter; and as probably the remaining inflammable matter is a constituent part of these alkalis, we need not be surprised that their properties are changed, and that even a decomposition of their parts should happen upon the quicklime depriving them of this inflammable matter, if the action of the quicklime be sufficiently applied. And accordingly it happens that by

a continued treatment of fixed and volatile alkalis with quicklime, they may be at laſt entirely deſtroyed.

As ſimple calcareous earths do not produce the ſame effects upon alkalis, it follows that quicklime has a more powerful action than thoſe earths upon inflammable matters; and accordingly we find that quicklime unites more intimately than calcareous earths with oils and with ſulphur, forming with this latter ſubſtance a kind of earthy liver of ſulphur, which is ſoluble in water to a certain degree.

This action of quicklime upon alkalis and upon inflammable matters is advantageouſly applied to give activity to the former, and to make them more capable of uniting with oils. Accordingly, the alkali employed in the compoſition of ſoap ought to be always ſharpened by quicklime. *See* SOAP, *and* LEY *of* SOAP-BOILERS.

Fixed alkali ſharpened by quicklime, and reduced to a ſolid conſiſtence by drying, is much more cauſtic than ordinary alkali, and is employed as a cautery. *See* CAUSTIC (COMMON).

The moſt general uſe of quicklime is for building. The property which ſlaked lime has, when mixed with ſand, of forming a *mortar* or cement capable of hardening and acquiring a ſtoney conſiſtence, renders it uſeful for the joining of ſtones of buildings, pavements, &c. This mortar has alſo the advantage of being impenetrable by water, when it has once become ſolid. *See* MORTAR.

Quicklime has medicinal virtues. As an abſorbent earth, it is anti-acid, and is capable of abſorbing any acids which are produced in the ſtomach by a debility of that organ, in the diſeaſes proceeding from a ſpontaneous acid, ſo well deſcribed by Boerhaave. It is ſo much better adapted to thoſe diſeaſes which are always cauſed by inactivity, and by the weakneſs and laxity of the fibres, as it has a tonic quality, which ſimple abſorbent earths have not. *See* EARTHS (ABSORBENT).

As quicklime is alſo drying, and ſomewhat cauſtic, and conſequently cicatriſing, it may contribute to the cure of certain ulcers, eſpecially of the ſoft parts: accordingly ſeveral able phyſicians have preſcribed it ſucceſsfully even for internal ſuppurations, and for the phthiſis of the lungs.

Laſtly, the property which quicklime has of attenuating viſcid matters, and of decompoſing ammoniacal ſalts, has been advantageouſly applied in theſe later times to diſſolve ſtones in the kidneys and bladder. An Engliſh phyſician has made on this ſubject ſome experiments capable of giving hopes of ſucceſs; and M. Roux, Doctor-Regent of the Faculty of Medicine at Paris, who has alſo given other proofs of his chemical abilities, has added conſiderably to theſe experiments; a relation of which, with his own additions, he has publiſhed in French (*l*)

(*l*) The experiments made by Dr. Black on quicklime, and related in the Eſſays phyſical and literary publiſhed at Edinburgh, have enabled that excellent chemiſt to form a new and ſatisfactory theory of the changes produced upon calcareous earths by means of calcination and of thoſe produced upon alkalis by means of quicklime. Theſe we have already mentioned under the articles AIR (FIXABLE), ALKALIS (FIXED *and* VOLATILE), and ſome others. We ſhall nevertheleſs place under one view the principal facts and doctrines concerning quicklime, and for more minute explanations and proofs, we refer to the above-mentioned articles, but eſpecially to the Eſſay itſelf above-quoted.

The best method of administering quicklime, especially for internal use,

The class of earths and stones called by naturalists *calcareous*, or chalks and marbles, or those which by calcination are convertible into quicklime, are found by experiments to consist of the following component parts. 1. Of *quicklime*, or pure and uncombined calcareous earth. The quantity of this in a piece of chalk was found by Dr. Black to be equal to $\frac{68}{120}$ of the whole, the remaining $\frac{52}{120}$ parts having been extricated by calcination. 2. Of *fixable air*, which when extricated is found to be permanently elastic, and uninflammable. Concerning its properties, *see* AIR (FIXABLE). The quantity of this air extricated from a piece of chalk, during its solution in an acid, was found by an experiment of Dr Black to be equal to $\frac{2}{5}$ of the whole mass; and the quantity of air extricated from a piece of marble was found by Mr. Cavendish to be $\frac{407}{1000}$ of the whole mass. As the results of the experiments made by these two gentlemen so nearly concur, we have reason to believe that mild calcareous earth is always united and saturated with a determinate quantity of fixable air. 3 Of *water*. A certain quantity of water is always extricated from calcareous stones during their calcination, and may be collected by distillation of these stones with a retort and receiver. The quantity of water obtained from the distillation of osteocolla, which is a calcareous earth, by Mr. Margraaf, was found to be equal to $\frac{1}{12}$ of the whole mass. Dr. Black found that chalk lost by calcination $\frac{52}{120}$ of its weight. If we deduct from that loss, the $\frac{2}{5}$ which he found by an experiment abovementioned was the quantity of fixable air contained in chalk, the remainder $\frac{4}{120}$ or $\frac{1}{30}$ will be the quantity of water, which is nearly equal to the quantity obtained from osteocolla. Hence also we have reason to believe that a certain determinate quantity of water is united with and saturates the calcareous earth, when mild, or united with fixable air. But when this earth is separated from its fixable air, it becomes then capable of uniting with a much larger quantity of water, which is also probably determinate, as we shall find when we consider the properties of quicklime.

These are the only component parts of the purer chalks, marbles, calcareous spars, and stalactites; but many of the stones and earths which are usually calcined for making quicklime, as many of the common lime-stones and marles, contain, besides the earth properly called calcareous, various other substances intermixed, as sand, or vitrifiable earth, clay, and metallic calxes Some of these, as sand and metallic calxes, if not in too large quantities, are useful ingredients in the composition of mortar. But we must in this article be understood to mean calcareous earth unmixed with any other matters. *The quantity of calcareous earth in any lime-stone may be discovered by observing how much of that stone is soluble in* marine or nitrous acids, and by adding to the solution of the calcareous earth some caustic volatile alkali, by means of which, if any other earth, as earth of alum, metallic earths, &c. have been dissolved by the acid, these will be precipitated, and the calcareous earth alone will remain dissolved. By comparing the weight of the stone originally employed with the weight of the undissolved and precipitated parts, the quantity of calcareous earth in that stone may be found: or this quantity may be precipitated from the acid in which it is dissolved, by adding to the above solution of calcareous earth some mild fixed or volatile alkali, till no further precipitation is occasioned.

Native calcareous earths and stones may be decomposed, or resolved into the above-mentioned component parts, by fire or by acids.

When they are exposed to fire, the water and the fixable air are volatilised, and separated from the earthy part, which remains singly, and is then quicklime.

When an acid is applied to native calcareous earths, their fixable air is disengaged, recovers its elasticity, and is dissipated, while the acid remains united with the earth and the water, forming a salt with basis of calcareous earth. *See* SALTS. The earth or quicklime may be separated from the acid by means of a fixed alkali, which having a greater disposition to unite with the acid, precipitates the earth. If the alkali employed be caustic, or deprived of fixable air, the earth precipitated will be also caustic, or quicklime. But if the al-

is lime-water, becauſe this water has all the medicinal properties of quicklime,

kali employed be mild, that is, combined with fixable air, this air will unite with the earth; and thus the quicklime will be rendered mild, or reſtored to its original ſtate of native calcareous earth, combined with air.

Quicklime has the following properties. 1. It is entirely ſoluble in water, with which it unites ſo rapidly, as to occaſion conſiderable heat. When expoſed to air, it imbibes moiſture from thence. When united with as much water as is ſufficient to make it a fluid paſte, it is called *ſlaked lime*. Water ſaturated with quicklime is called *lime-water*. According to Brandt, lime-water contains about one part of quicklime to ſeven or eight hundred parts of water. Slaked lime, or lime-water, being expoſed to the atmoſphere, attract from thence particles of fixable air which float in it, by which means the quicklime is rendered mild, unſoluble in water, and therefore appears on the ſurface of the lime-water or of the ſlaked lime where this combination happens, in the ſtate of mild or combined calcareous earth, convertible by a ſecond calcination into quicklime, and is called *cream of lime*.

If the earth diſſolved in lime-water be precipitated from thence by any ſubſtance containing fixable air, as by mild alkalis, or magneſia, it will unite with this air, become mild, and reſume its former weight and properties which it poſſeſſed before calcination. But if it be precipitated from the water by means of ſome ſubſtance which does not contain fixable air, but which is more ſtrongly diſpoſed than the earth to unite with the water, for inſtance, ſpirit of wine, the earth thus precipitated will be in the ſtate of quicklime, that is, cauſtic, and ſoluble in water.

2. Quicklime unites with acids without effervescence, which is nothing elſe than an extrication of the fixable air, of which quicklime has been already deprived. It nevertheleſs ſaturates as much acid as it would have done if it had not been calcined.

3. Quicklime is more powerfully diſpoſed to unite with fixable air than fixed or volatile alkalis, or magneſia. Hence, when treated with theſe ſubſtances, it takes from them their fixable air, and is itſelf rendered mild, and reſtored to its original weight and properties. Thus two drams of chalk, having been by calcination reduced to one dram and eight grains of quicklime, were thrown into a filtrated ſolution of an ounce of mild fixed alkali in two ounces of water, and digeſted during ſome time; by which the calcareous earth became mild, and weighed one dram and fifty-eight grains. By means of magneſia, the calcareous earth may be precipitated from lime-water, and this earth is found to be mild, and to have deprived the magneſia of its fixable air. By depriving alkalis of their fixable air, quicklime renders them more cauſtic and ſolvent, for the ſame reaſon that itſelf is by this privation of air rendered more cauſtic and powerfully ſolvent. This increaſe of cauſticity and diſſolving power is conſiſtent with a general rule, namely, that the more ſimple or leſs compounded any body is, that is, the leſs its general tendency to union is ſatisfied, the more diſpoſed it is to unite with or diſſolve other ſubſtances. *See* AIR (FIXABLE), ALKALIS.

4. Quicklime has a diſpoſition to unite with ſulphur, with which it forms a hepar of ſulphur, ſimilar to that made by ſulphur united with an alkali, and, like this, ſoluble in water. It is alſo diſpoſed to unite with oils and with animal and vegetable matters, by which means it poſſeſſes a cauſtic and corroſive property.

5. Quicklime mixed with ſand forms a maſs which hardens, and is uſed as a cement or mortar. The hardening ſeems to be occaſioned by a cryſtallization of the calcareous earth when the ſuperfluous water is exhaled, and is ſimilar to the hardening of calcined gypſum or plaſter of Paris, when mixed haſtily with a ſufficient quantity of water to effect the cryſtallization of its minute particles. The uſe of the ſand added to quicklime in making mortar is to prevent thoſe cracks which would be formed by the drying of the calcareous earth, and by which its coheſion would be greatly diminiſhed. This effect the ſand produces, by dimi-

and becauſe the parts of the quicklime diſſolved in it are exceedingly fine, and conſequently perfectly diſtributed. *See* WATER (LIME).

niſhing the proportion which the contraction of dimenſions, occaſioned by drying, bears to the dimenſions of the whole maſs, which is to be thus expoſed to contraction and drying; the ſand being itſelf incapable of ſuffering any contraction.

R.

DLXXVII. RAIN. *See* WATER.

DLXXVIII. REALGAR, *or* REALGAL. These names have been given to compositions of sulphur and arsenic. These two substances are capable of uniting together, especially when they are reduced to vapors, and sublimed together. The whiteness of crystalline arsenic is always altered by union with sulphur; and the new compound becomes yellow, inclining more or less to an orange, or even to a red color, according to the quantity of sulphur united with the arsenic. When the sulphur is only a tenth part of the whole mixture, the sublimate is yellow. It is then called *yellow realgar*, or *yellow arsenic*, and in commerce *orpiment*.

When the sulphur is a fifth part of the combination, the sublimate is red. It is then called *red realgar*, *sandarach*, *red arsenic*, &c. To few substances have so many names been given as to arsenic and its compounds, as may be seen in several authors of mineralogy, and particularly in Henckel's Pyritologia.

As sulphur fixes arsenic a little, the red realgar may be melted with a gentle heat; and when it has become solid, it is transparent, and then is called *ruby of sulphur*, or *arsenical ruby*.

These combinations of arsenic and sulphur are not generally made in laboratories, because they do not succeed well, as Henckel remarks, when pure arsenic and pure sulphur are sublimed together. They are prepared in countries abounding in ores, which are smelted by mixing together some that contain arsenic, as the *white pyrites*, with others that contain sulphur, like the *sulphureous pyrites*, or *sulphureous scorias*, the quantity of each of which is proportioned as experience taught.

These artificial combinations of sulphur and arsenic ought to be distinguished from those which nature offers to us ready made, as orpiment. They have been very improperly confounded by several authors. Both the natural and artificial compounds are poisons, although Hoffman says that the natural orpiment

piment is not poisonous. The yellow and red artificial arsenics are probably more pernicious. The principal use of these substances is for painting.

When arsenic and sulphur are thus well combined together by sublimation, they cannot be separated without some intermediate substance, because they are volatile: but this separation may be effected by means of fixed alkali or mercury. *See* ARSENIC.

DLXXIX. RECEIVER. Receivers are chemical vessels, which are adapted to the necks or beaks of retorts, alembics, and other distillatory vessels, to collect, receive, and contain the products of distillations.

Receivers ought to be made of glass, not only because this matter resists the action of the strongest and most corrosive substances, but also because being transparent it allows the operator to see through it, and to judge by the frequency of the drops, if the distillation be too fast or too slow, and also if the quantity and nature of the substances which come over be such as is required.

Almost all receivers are kinds of bottles of different sizes, of a spherical form, the necks of which are cut short, and each of which is pierced with a small hole in its lateral or upper part, to give vent to the air or vapors which are too expansive. Receivers of this form are called *balloons*. *See* BALLOON.

Some receivers are matrasses with long necks. These are generally adapted to the beaks of glass alembics. This long neck serves to keep the belly of the receiver, where the liquor is collected, at a proper distance from the fire.

Receivers have different forms for particular operations. Such are those which have two or three beaks, either to be adapted to other receivers, or to admit at the same time the necks of several distillatory vessels, when the intention of the operator is that the vapors of different substances should meet in the same receiver. Such also are *receivers for essential oils*, which are very convenient for the distillation of these oils. To obtain the essential oil of aromatic plants, these plants must be distilled with water. The plant and the water are to be put together into a cucurbit, and the water, which is to receive a boiling heat, rises in distillation, carrying with it the essential oil, which also has the property of rising with this degree of heat. *See* OILS.

As a large quantity of water must be employed, that the plant may always be kept immersed in the alembic, and consequently as a good deal of it rises in proportion to the oil, any receiver of ordinary size would be soon filled with water, with a little oil floating upon its surface; and would require to be frequently changed, which would be very troublesome, and would occasion a loss of part of the oil.

These inconveniencies are avoided by using receivers contrived purposely for such distillations. They are so made, that they are never full, but that the water runs out, and leaves the oil behind. They are a kind of glass cucurbits, which contract as they rise higher; so that their neck or upper opening is but nearly of a convenient size to receive the beak of the *worm*. These receivers have another opening about the middle of the swelling or belly; and to this opening is joined a glass tube, which bends and rises vertically along the outer part of the receiver, so as to be within two inches and a half as high as the upper opening. At this height the tube bends again towards the side opposite

to the body of the receiver, to pour into another veſſel the liquor which riſes there. It forms the figure of S.

When this receiver is to be uſed, it is to be placed vertically under the beak of the worm. During the diſtillation, the liquor riſes to an equal height in the body of the receiver and in the crooked tube: when therefore the height of the liquor in the receiver becomes greater than the height of the tube, it muſt begin to flow from the mouth of this tube into another veſſel placed on purpoſe to receive it: but as eſſential oils are either lighter or heavier than water, and as they are therefore always collected either above or under the water, and as the liquor which diſcharges itſelf through the tube is taken from the middle part of the receiver, therefore nothing but water can be evacuated at the mouth of the pipe, while the oil always remains in the receiver. Thus, with ſuch a receiver, we may diſtill without the trouble of changing the veſſels; which is certainly very advantageous.

DLXXX. RECTIFICATION. By rectification is meant the exact purification of certain ſubſtances, by means of *diſtillation* or of *ſublimation*.

This operation is neceſſary to diſengage many chemical products or agents from a mixture of extraneous matters which deſtroy their purity. Thus, for inſtance, vitriolic acid, when firſt obtained from *vitriol* or from *ſulphur*, is always charged with a conſiderable quantity either of inflammable matter, which renders it black and ſulphureous; or of ſuperabundant water, which weakens it. It is ſeparated from both theſe matters by a ſecond diſtillation, in which they being more volatile than the acid, are carried off; which ſecond diſtillation is called *concentration* or *rectification of vitriolic acid*. *See* CONCENTRATION *of* VITRIOLIC ACID.

Alſo when animal and vegetable matters are decompoſed by diſtillation, all the portion of oil that is not volatile contained in theſe ſubſtances does not riſe but with a degree of fire ſo ſtrong as to burn a part of them, and to raiſe along with them a conſiderable portion of ſaline ſubſtances, which, being mixed with the oily part, conſiderably alter its purity. To purify theſe oils, which, from their burnt ſmell, are called *empyreumatic*, new diſtillations muſt be applied, in which, by means of a leſs heat, the moſt volatile and pureſt part of theſe oils is ſeparated from the moſt empyreumatic and ſaline parts, which remain at the bottom of the retort: this is called the *rectification of empyreumatic oils*. *See* OIL (RECTIFIED ANIMAL) *or of* DIPPEL.

The ardent ſpirits obtained by a firſt diſtillation of liquors which have undergone the ſpirituous fermentation, are overcharged with a large quantity of phlegm and light oil, which riſe along with them in this firſt diſtillation. The product of this diſtillation is called *aqua vitæ*. It is an ardent ſpirit very far from the degree of dephlegmation and purity which good ſpirit of wine ought to have to render it fit for chemical operations, and for ſeveral compounds commonly uſed, ſuch as perfumed waters and *liqueurs* for the table. This ſpirit of wine is to be purified, or rather the aqua vitæ is to be changed into ſpirit of wine by new diſtillations, ſlowly conducted with a gentle fire and water-bath, by means of which the moſt volatile part that always riſes firſt with the leaſt heat, and which is the true ſpirit of wine, is ſeparated from the leſs volatile part that remains in the alembic, and which contains the phlegm and

oil

oil of wine, by which the ſpirit of wine was rendered impure. The firſt liquor of theſe ſecond diſtillations or rectifications is called *rectified ſpirit of wine. For its properties ſee* SPIRIT (ARDENT).

When only a ſmall quantity of ſpirit of wine is to be rectified, the operation is difficult, eſpecially when we would have it perfectly rectified. The cauſe of this difficulty proceeds from the very ſmall quantity of the firſt liquor obtained in this rectification. Several chemiſts, to obtain a larger quantity of the firſt ſpirit, propoſe to mix with the ſpirit of wine ſome intermediate ſubſtances to abſorb and retain its phlegm and oil, ſuch as dried and calcined ſalts, very dry chalk, &c. Kunckel propoſes to ſeparate more effectually the oil, by adding to the ſpirit a large quantity of water, and by diſtilling this diluted ſpirit with a very gentle heat. This method is indeed very capable of facilitating the ſeparation of the oil of wine from the ſpirit of wine; becauſe this oil certainly adheres to the ſpirit, which is the chief obſtacle to its ſeparation; and becauſe the ſpirit of wine has greater affinity with water than with oil; ſo that when it is diluted with much water, it quits the oil to unite with the water. This expedient of Kunckel is therefore very good to facilitate the ſeparation of ſpirit of wine from the oil which renders it impure; but, on the other hand, when it is practiſed, we are afterwards obliged to deprive the ſpirit of wine of the water with which it was diluted.

All this trouble and inconvenience may be avoided by rectifying at once a large quantity of aqua vitæ. Nothing more is required to obtain at once a conſiderable quantity of pure ſpirit of wine, than to ſet aſide the twelve or fifteen pints firſt drawn over from a large quantity, ſuppoſe from three hundred pints of aqua vitæ, diſtilled with a very gentle fire in a large alembic. As the moſt ſpirituous, leaſt aqueous, and leaſt oily part of it always riſes firſt, theſe twelve or fifteen pints are perfectly rectified ſpirit of wine, eſpecially when the heat has been well conducted. By thus keeping apart portions of the ſpirit obtained at different times, we may have ſpirit of wine of the ſeveral degrees of ſtrength and purity. The weaker ſpirit may, by another diſtillation, be again rectified. Laſtly, the ſpirit of moderate ſtrength may be preſerved, as it is fit for many uſes. This method is followed by Mr. Beaumé in the rectification of ſpirit of wine, and is certainly the moſt convenient and the beſt.

The volatile ſalts obtained in the decompoſition of certain oily ſubſtances, as volatile alkalis, from decompoſed animal matters, are always very impure, and ſpoiled by much fetid empyreumatic oil, which riſes along with them. They are purified and diſengaged by ſubjecting them to new diſtillations or ſublimations with a well conducted heat. The ſame obſervation is applicable to butter of antimony, artificial cinnabar, phoſphorus, and of many other chemical products, which are always impure when obtained by a firſt operation, and muſt therefore be purified by a ſecond diſtillation or ſublimation. All theſe ſecond operations, intended merely to purify matters, are called rectifications. They are not generally attended with much difficulty. We ſhall not therefore enter into the details of them; but we ſhall obſerve only, that all rectifications are founded upon the ſame principle. They all conſiſt in ſeparating ſubſtances more volatile from ſubſtances leſs volatile; and the general method of effecting this is to apply only the degree of heat which is neceſſary to cauſe this ſeparation. *See* DISTILLATION *and* SUBLIMATION.

DLXXXI.

DLXXXI. R E D. (m)

DLXXXII. R E D U C T I O N *or* R E V I V I F I C A T I O N. This word, in its most extensive sense, is applicable to all operations by which any substance is restored to its natural state, or which is considered as such: but custom confines it to operations by which metals are restored to their metallic state after they have been deprived of this state, either by the loss of their phlogiston, as metallic calxes, or by the union of some heterogeneous matters which disguise them, as *fulminating gold*, *luna cornea*, *cinnabar*, and other compounds of the same kind. These *reductions* are also called *revivifications*. We shall treat of both these kinds of reduction.

The reduction of metallic calxes regards only imperfect metals; because these alone are susceptible of losing their metallic properties by the loss of phlogiston. They may be deprived of this principle by the action of air or of water, which changes them to *rust*; or by the action of acids, particularly of the nitrous and vitriolic; or, lastly, by ordinary calcination, that is, by the combustion of their phlogiston in an open fire.

Metals deprived of their phlogiston by any of these causes have not their peculiar color, lustre, ductility, nor even consistence and gravity. They have the appearance of earths, the parts of which are unconnected, unless they have sustained a fire violent enough to fuse them; and then they become brittle vitrified matters.

But these metallic earths, calxes, or glasses, are capable of being again combined with the inflammable principle, and of recovering all the metallic properties. For this purpose their calcination or dephlogistication must not have been too compleat, and the phlogiston must be applied in a state favorable for combination. These calxes, particularly those of metals which cannot be radically calcined, as lead, bismuth, iron, and copper, may recover their phlogiston, and may be reduced even without fire or fusion, merely by the contact of phlogistic vapors; for instance, by the vapor of liver of sulphur; or they may be reduced in the humid way, that is, when they are precipitated by some substance capable of applying phlogiston to them.

But we must observe, that metals reduced by either of these methods are only superficially so, when the metallic masses are considerably large; and that when the metals thus reduced consist of fine molecules, these molecules, although well reduced and provided with all their metallic properties, remain always disjoined and separated from each other; either because they are not small enough, or because they have not time to unite and agglutinate together, as they have when they are combined by nature; for metals are certainly formed naturally by these methods: but the operations of our laboratories are very different from those of nature. Accordingly, in practical chemistry a much more expeditious method for making these reductions is employed; which is fusion.

The reduction of metallic calxes by fusion is generally a quick and easy operation. It, however, requires certain attentions and management; which are:

(m) RED. Concerning the substances which give a red color to stuffs, glass, enamels, &c. *see the articles* FLOWERS, FRUITS, COCHINEAL, MADDER, KERMES, LAC, DYING, MANGANESE, POWDER *of* CASSIUS, ENAMEL.

are: 1. To mix accurately the metallic calx to be reduced with the proper quantity of the matter which is to give it phlogiston. 2. To add to the mixture some saline or vitreous matter capable of facilitating the fusion and separation of the reduced metal from the scoria. 3. To prevent any communication with external air, that the phlogiston may not be burnt and consumed. 4. To keep the fire low at first, that the too great swelling, which is generally occasioned by the re-action of the inflammable principle with metallic earths, may be prevented; and to raise the fire towards the end, so that not only the metal, but also the supernatant scoria, may be perfectly fused; whereas if the scoria was not well fused and tenacious, it would retain much of the reduced metal, and prevent it from falling down to the bottom of the crucible.

The operations must be very exactly performed, especially in essays of ores, in which the precise quantity of metal is required to be known. These essays of ores are in some measure the only reductions of this kind which are performed in practical chemistry, as the reduction of pure metallic calxes differs only from the former in requiring a less quantity of flux; because these calxes do not, as the ores do, contain a difficultly fusible earthy or stony matter: we therefore refer to the article ESSAY *of* ORES. Here we shall only observe, that when we treat very volatile semi-metals, as zinc and arsenic, the reduction ought to be made in vessels perfectly close; for instance, in an earthen retort. We find after the reduction these metallic matters sublimed in the vault or neck of the retort.

The reduction of metals which do not lose their inflammable principle, as gold, silver, and mercury, is of another kind. As these metals can be only disguised by the union they have contracted with some heterogeneous substance, they are to be reduced, not by restoring phlogiston, but by some intermediate substance capable of separating from them the matter which is united with them. These intermediate substances must therefore differ according to the matter united with the metal.

For instance, fulminating gold may be reduced by fusing it with sulphur, or with fixed alkali; because either of these substances is capable of decomposing the nitrous ammoniacal salt which gives the fulminating property to gold. *See* GOLD (FULMINATING). Luna cornea also is reduced by fusing it with a large quantity, as, for instance, with twice its weight of fixed alkali; because in this reduction the marine acid united with the silver is to be separated, and the fixed alkali is capable of effecting that separation. The reduction of luna cornea is attended with difficulties, because this compound is semi-volatile and very penetrating; so that when it is exposed to fire, some part of it is always lost, whether it exhales in vapors or penetrates the crucible. Several chemists recommend the reduction of luna cornea by fusing it with fat matters, which, from experience, I know to be a very bad method; for the marine acid has a strong affinity with silver, and has no disposition to unite with phlogiston, or even with substances which contain much of it.

Luna cornea may also be well reduced by precipitation, and by treating it with other metals which have more affinity than silver with marine acid, such as tin, iron, regulus of antimony. Mr. Margraaf gives, in his *Opuscules Chemiques*, a process which deserves a place here; because, according to this excellent chemist,

mist, a very pure silver is obtained, and without any loss. It consists in mixing well, in a glass mortar, luna cornea with some concrete volatile alkali, in the proportion of about five gros of luna cornea with an ounce and a half of volatile salt, to which a little water is to be added to give to the mixture a soft consistence. This mixture swells with a kind of effervescence. After it has been triturated a quarter of an hour, three ounces of very pure mercury revived from cinnabar are to be added. The trituration is to be renewed for two or three hours, and half a gros of volatile alkali is to be added, to replace that which is dissipated; and afterwards a larger quantity of water. Upon the addition of this water appears a fine amalgam of silver, which is to be washed several times, till the water comes off clear. This amalgam is then to be distilled, by which the mercury is expelled, and all the silver which was contained in the luna cornea remains pure, excepting about four grains which have been washed away.

The mercury of cinnabar is to be reduced or separated from sulphur, by mixing with the cinnabar any substance which has greater affinity with the sulphur than mercury has, such as fixed alkalis, absorbent earths, iron, copper, lead, silver, or regulus of antimony. Filings of iron are generally employed in this operation, an equal weight of which is to be mixed with the cinnabar, and the whole distilled together, by which the mercury will be raised and collected at the bottom of the receiver under some water placed there to facilitate its condensation The sulphur of the cinnabar remains in the retort united with the intermediate substance employed for the separation. This mercury is called *mercury revived from cinnabar*. It is justly considered as very pure.

DLXXXIII. REFINING. Refining is a term used in chemistry and several arts to signify the purification of some substance, particularly of metals, as gold, silver, copper, iron, &c.

We shall here treat only of the refining of gold and silver; and for the refining of other substances we refer to their several articles.

Gold and silver may be refined by several methods, which are all founded on the essential properties of these metals, and acquire different names according to their kinds. Thus, for instance, gold, having the property which no other metal, not even silver, has, of resisting the action of sulphur, of antimony, of nitrous acid, of marine acid, may be purified by these agents from all other metallic substances, and consequently may be refined. These operations are distinguished by proper names, as *purification of gold by antimony*, *parting*, *concentrated parting*, *dry parting*. In a similar manner, as silver has the property, which the imperfect metals have not, of resisting the action of nitre, it may be refined by this salt: but the term *refining* is chiefly applied to the purification of gold and silver by lead in the cupel. We shall therefore treat only of this latter manner of purifying these metals, referring for the others to the words PURIFICATION *and* PARTING. *See these words.*

The refining of gold and silver by lead in the cupel is made by the destruction, vitrification, and scorification of all the extraneous and destructible metallic substances with which they are allayed.

As none but the perfect metals can resist the combined action of air and fire, without burning, that is, without losing their inflammable principle, their metallic properties and forms, and without being changed into earthy or vitreous matters, incapable of remaining any longer united with substances in a metallic state, there

there is then a poſſibility of purifying gold and ſilver from all allay of imperfect metals merely by the action of fire and air; only by keeping them fuſed till all the allay be deſtroyed: but this purification would be very expenſive, from the great conſumption of fuel, and would be exceedingly tedious. I have ſeen ſilver allayed with copper, expoſed longer than ſixty hours to a glaſs-houſe fire without being perfectly refined: the reaſon of which is, that when a ſmall quantity only of imperfect metal remains united with gold or ſilver, it is covered and protected from the action of the air which is neceſſary for the combuſtion of the imperfect metals, as of all combuſtible matters. *See* CALCINATION.

This refining of gold and ſilver merely by the action of fire, which was the only method anciently known, was very long, difficult, expenſive, and imperfect: but a much ſhorter and more advantageous method has been diſcovered. This method conſiſts in adding to the allayed gold and ſilver a certain quantity of lead, and in expoſing afterwards this mixture to the action of the fire. Lead is one of the metals which loſes moſt quickly and eaſily enough of its inflammable principle to ceaſe to be in a metallic ſtate; but, at the ſame time, this metal has the remarkable property of retaining, notwithſtanding the action of the fire, enough of this ſame inflammable principle to be very eaſily melted into a vitrified and powerfully vitrifying matter, called *litharge*. *See* LITHARGE.

The lead then which is to be added to the gold and ſilver to be refined, or which happens naturally to be mixed with theſe metals, produces in their refining the following advantages: 1. By encreaſing the proportion of imperfect metals, it prevents them from being ſo well covered and protected by the perfect metals. 2. By uniting with theſe imperfect metals, it communicates to them a property it has of loſing very eaſily a great part of its inflammable principle. 3. Laſtly, by its vitrifying and fuſing property which it exerciſes with all its force upon the calcined and naturally refractory parts of the other metals, it facilitates and accelerates the fuſion, the ſcorification, and the ſeparation of theſe metals. Theſe are the advantages procured by lead in the refining of gold and ſilver.

The lead which in this operation is ſcorified, and ſcorifies along with it the imperfect metals, ſeparates from the metallic maſs, with which it is then incapable of remaining united. It floats upon the ſurface of the melted maſs; becauſe by loſing part of its phlogiſton, it loſes alſo part of its ſpecific gravity, and laſtly it vitrifies.

Theſe vitrified and melted matters accumulating more and more upon the ſurface of the metal while the operation advances, would conſequently protect this ſurface from the contact of air which is abſolutely neceſſary for the ſcorification of the reſt, and would thus ſtop the progreſs of the operation, which could never be finiſhed, if a method had not been contrived for their removal. This removal of the vitrified matter is procured either by the nature of the veſſel in which the melted matter is contained; and which being porous, abſorbs and imbibes the ſcorified matter as faſt as it is formed, or by a channel cut in the edge of the veſſel through which the matter flows out.

The veſſel in which the refining is performed is flat and ſhallow, that the matter which it contains preſents to the air the greateſt ſurface poſſible. This form reſembles that of a cup, and hence it has been called *cupel*. *See* PLATE I. *Fig.* 10. The furnace ought to be vaulted, that the heat may be applied upon the ſurface

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of the metal during the whole time of the operation. Upon this ſurface a cruſt or dark-colored pellicle is continually forming. In the inſtant when all the imperfect metal is deſtroyed, and conſequently the ſcorification ceaſes, the ſurface of the perfect metals is ſeen, and appears clean and brilliant. This forms a kind of *fulguration* or *coruſcation*. By this mark the metal is known to be refined. If the operation be ſo conducted that the metal ſuſtains only the preciſe degree of heat neceſſary to keep it fuſed before it be perfectly refined, we may obſerve that it fixes or becomes ſolid all at once in the very inſtant of the coruſcation; becauſe a greater heat is required to keep ſilver or gold in fuſion, when they are pure, than when allayed with lead.

The operation of refining may be performed in ſmall or in large quantities, upon the ſame principles, but only with ſome differences in the management. As the refining of ſmall quantities of perfect metals is performed in the ſame manner as theſe metals are eſſayed, the eſſay being only a very accurate refining, we refer to the article ESSAY *of the* VALUE *of* SILVER.

Large quantities of ſilver are thus purified, after the operations by which that metal is obtained from its ores. This ſilver, being always much allayed, is to be mixed with a ſufficient quantity of lead to compleat its purification, unleſs lead has been added in its firſt fuſion from the ore, or unleſs it has been extracted from an ore which alſo contains lead; in which latter caſe, it is allayed naturally with a ſufficient quantity, or more than ſufficient, for the refining of it. *See* ORES *of* SILVER. One of the ores of this kind, which is treated in the beſt manner, is the ore of Ramelſberg in Saxony. The ſeveral operations which are practiſed in this country, abounding in mines and excellent metallurgiſts, have been exactly deſcribed by Schlutter. We ſhall here give a ſuccinct extract of the method of purifying large quantities of ſilver, from Hellot's tranſlation of Schlutter's work.

The workmen give the name of *the work* to the lead containing ſilver, obtained by ſmelting the ore of Ramelſberg. The firſt operation, called *fining*, upon this maſs of lead and ſilver, is performed in a furnace called a reverberatory furnace, from the vaulted form, which makes the heat reverberate upon the ſurface of the metal. *See a plan and ſection of this furnace*, PLATE II. *Fig.* 16 *and* 17. This furnace is ſo conſtructed, that the flame of the wood, which is put in the fire-place through a hole called the fire-hole, is directed ſo as to circulate over the *work* within the furnace. The flame is thus directed by a current of air which is introduced through the aſh-hole, and paſſes out at an opening made at the ſide of the place where the work is. The wood is conſiderably ſaved by this direction of the flame. In the furnace a large cupel or teſt is to be diſpoſed. This teſt is to be made with aſhes of beech wood well lixiviated, that the ſalt may be waſhed from them. *See* CUPEL. In ſome founderies different matters are added to the aſhes, as ſand, lime, clay, calcined ſpar or gypſum. We may obſerve, concerning theſe additions, that they would be very injurious, and would make the teſt melt, if a ſtrong heat were applied; but the heat requiſite for fining is only moderate. *See at the word* ESSAY *the inconveniences and marks of too ſtrong a heat.*

When the teſt is well prepared and dried, all the *work* is to be put into it at once, which is generally ſixty-four quintals: the fire is then to be made in the fire-place with faggots; but the fuſion is not to be too much haſtened, firſt, that the teſt may have time to dry thoroughly, which is very eſſential; for if

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any moiſture remained when the metal is melted, an exploſion might happen: ſecondly, becauſe the *work* of the ore at Ramelſberg, and of moſt others, is rendered impure by the mixture of many metallic matters, which ought to be ſeparated, otherwiſe they would ſpoil the litharge, and give a bad quality to the lead afterwards obtained from that litharge. Theſe extraneous matters found in the *work* of Ramelſberg are, copper, iron, and matt. As theſe ſubſtances are hard and refractory, they do not melt ſo ſoon as the *work*, if the heat be moderate; and beſides, as they are ſpecifically lighter than the mixture of lead and ſilver, they float upon the ſurface of theſe two metals when melted, in form of a pellicle or ſkin, which is to be taken off. Theſe impurities are called the ſcum or firſt droſs. The remainder forms alſo a ſcum, which appears when the work has received more heat, but before the litharge has begun to form. This is a ſcoria which is to be carefully taken off, and is called the ſecond droſs.

When the operation is come to this point, it is to be continued by means of bellows, the air of which is directed not on the wood, but on the ſurface of the metals, by means of iron plates placed for that purpoſe before the blaſt-hole, and which are called papillions. This air is not intended to encreaſe the fire, but to facilitate the combuſtion of the lead, and to puſh the litharge to a channel in the oppoſite ſide of the teſt. This channel is called *the way of the litharge*, becauſe through this paſſage all the litharge, which is not imbibed by the teſt, flows out of the furnace. The litharge which is found in the middle of the large lumps is friable, and crumbles into powder like ſand. It is put in caſks, each of which contains five quintals of it, and is ſold by the name of *ſaleable litharge*. It is uſed for various purpoſes, and particularly for glazing of earthen ware. The other part which remains is called *cold litharge*. It is remelted and reduced to lead. This fuſion is called *cold fuſion*, and the lead produced from it, called *cold lead*, is good and ſaleable, when the work has been well purified from the extraneous matters mentioned above. The teſts impregnated with litharge are added to the ſame kind of ore when ſmelted; becauſe they contain not only much litharge, which may be reduced to lead, but alſo ſome ſilver, in all refinings, whether in great or in ſmall, as Mr. Tillet obſerves.

When about two-thirds of the work are converted into litharge, no more of it is formed: the ſilver is then covered with a ſort of white ſkin, which the refiners call *lightening*; and they call the metal *lightened ſilver* or *fined ſilver*. The ſilver thus fined is not pure: every mark of it contains about four gros of lead: it is given to workmen, who compleat the purification of it in the ordinary method, that is, by a ſecond cupellation with a hotter fire; which latter purification is called *refining*, and the perſons who perform it are called *refiners*. The workmen employed in this firſt operation or fining give improperly the name *lightening* to the white ſkin formed on the ſurface of the ſilver, when brought only to a certain degree of fineneſs; for we know that in eſſays the lightening or coruſcation above-mentioned does not appear but when the ſilver is perfectly fine, or, at leaſt, as fine as it can be made by cupellation.

A fining of ſixty-four quintals of work of Ramelſberg yields about eight or ten marks of fine ſilver, thirty-five or forty quintals of litharge, that is, from twelve to eighteen of ſaleable litharge, from twenty-two to twenty-three of

 cold

cold litharge, from twenty to twenty-two quintals of tests, and six or seven quintals of dross. The operation lasts from sixteen to eighteen hours.

If the silver before these operations was allayed with gold, it retains it still after the fining and refining. The gold, if the quantity be considerable enough, may be separated by parting. The operations for the purification of gold by cupellation are perfectly the same as those of silver. If the gold to be fined contains silver, this silver remains with it after the operation; because both these metals resist the action of lead. The silver may afterwards be separated by parting.

DLXXXIV. REFRACTORY. This word is applied to unfusible substances, or those which cannot be melted in a violent fire.

DLXXXV. REFRIGERATORY. A refrigeratory is a copper vessel soldered round the capital of the alembic. Its use is to contain cold water, which is to be renewed when it is heated, and the hot water is to be let out at a cock fitted to the refrigeratory for this purpose. The intention of this renewal of the water of the refrigeratory is to keep perpetually cool the capital of the alembic, that the vapors of the liquor which rise in distillation may be condensed more easily and more quickly. These refrigeratories were much used formerly, and all alembics were furnished with them: but modern distillers find that this vessel is not attended with the advantages formerly believed; for the distillation cannot succeed unless the capital of the alembic be as hot, or almost as hot, as the cucurbit. Mr. Beaumé observed, that when the capital was cooled by very cold water, the distillation is soon stopped, and does not again begin till the capital is consideraly heated.

The refrigeratory has for these reasons been much neglected, and a *worm* substituted in place of it, which is indeed a kind of refrigeratory, but different from the other in this respect, that it is adapted to the nose of the alembic, instead of surrounding the capital. *See* ALEMBIC, DISTILLATION, *and* WORM. *See also* PLATE I. *Fig.* 8.

DLXXXVI. REGISTER. Registers are openings in different parts of furnaces, which are to be shut occasionally with stoppers of burnt clay. By means of registers we may govern the fire as we please; for by opening or shutting them properly we may not only encrease or diminish the activity of the fire, but also we may apply its action more to one part of the furnace than another, by giving direction to the current of air which passes thro' it. Notwithstanding the utility of registers, they are much neglected. Many chemists have disused registers, probably because they did not find the advantages from them which they expected. The reason of this is, that registers have hitherto been ill made Their principal fault is, that they are generally too small. A register cannot have its proper effect unless it have an opening of two, three, or four inches, for a furnace, the internal diameter of which is a foot: but we frequently see furnaces of eighteen or twenty inches diameter, with registers, the openings of which are scarcely eight or ten lines. Besides, all those who use furnaces are far from understanding their construction. *See* FURNACE.

DLXXXVII REGULUS. The name *regulus* is given by chemists to metallic matters when separated from other substances by fusion. This name was introduced by alchemists, who expecting always to find gold in the metal

metal collected at the bottom of their crucibles after fuſion, called this metal thus collected, *regulus*, as containing gold, the king of metals. But although, ſince the cultivation of philoſophical chemiſtry, theſe metallic maſſes compoſed of ſeveral metals mixed together are frequently called by this name, yet it is more particularly applied to certain ſemi-metals which have no proper name, ſuch as the *regulus of antimony*, *regulus of arſenic*, and *regulus of cobalt*.

DLXXXVIII. REGULUS *of* ANTIMONY. Regulus of antimony is the ſemi-metallic ſubſtance contained in mineral antimony, after it has been ſeparated by proper operations from the ſulphur which mineraliſes it.

This ſemi-metal, when very pure and well-fuſed, is of a white ſhining color, and is compoſed of laminæ applied to each other. It is one of the metallic matters which moſt eaſily takes the regular arrangement of parts which is proper to it. When it has been well fuſed, and afterwards cooled not too haſtily, and when its ſurface is not obliged to conform to the ſhape of any ſolid matter which touches it during the time of its hardening, its regular arrangement becomes ſenſible both externally and internally. This kind of cryſtalliſation forms then upon the upper ſurface of the regulus of antimony a ſort of ſtar, compoſed of many radii iſſuing from one center. Alchemiſts diſpoſed to the marvellous, imagined this to be very myſterious and ſignificative, and that it was nothing leſs than a ſtar appearing to magi or ſages to conduct them to the [illegible] of the king. But this wonder has been reduced by Stahl in his *Op[illegible]um Chemicum*, and by Mr. Reaumur in a Memoir of 1724, to what it really is; that is, to the regular arrangement of the integrant parts of the regulus of antimony, when, by a perfect fuſion and ſlow cooling, they have had time and opportunity to place themſelves in that diſpoſition to which they naturally tend from their primary form: and ſince that time, chemiſts have found that this phenomenon is common to all metallic matters, which form, in ſimilar circumſtances, not ſtars, becauſe the integrant parts of each have peculiar ſhapes, but different figures no leſs regular and dependent on the form of theſe parts. It is an effect abſolutely ſimilar to the regularity of the figure of ſalts in their cryſtallization. *See* CRYSTALLIZATION.

Regulus of antimony is moderately hard, but, like the other ſemi-metals, it has no ductility, and breaks in ſmall pieces under a hammer.

It loſes $\frac{1}{7}$ part of its weight in water. The action of the air and of water deſtroys its luſtre, as it does to all imperfect metals, but it does not deſtroy and ruſt it ſo effectually as it does copper and iron.

This ſemi-metal is fuſible with a moderate heat, and as ſoon as it begins to be red-hot: but when it is heated to a certain degree, it fumes continually, and is diſſipated in vapors, becauſe it is ſemi-volatile, like the other ſemi-metals.

The fumes of regulus of antimony, when paſſing through air, form what are called *argentine flowers of regulus of antimony*. They are nothing but the earth of this ſemi-metal deprived of part of its inflammable principle, and capable of being reduced to the ſtate of regulus by its union with this principle. *See* FLOWERS (ARGENTINE).

This regulus, by calcination with a moderate fire, is deprived of more and more of its phlogiſton, and is changed ſucceſſively firſt into a grey calx capable of being fuſed by a ſtronger heat either into a vitreous and brittle matter, but

brown

brown or opake, or to a reddifh tranfparent glafs, according to its degree of calcination. The former matter is a *liver of antimony*, and the latter a *glafs of antimony*. *See thefe words.*

If the calcination be continued longer, the calx of the regulus of antimony lofes more and more of its phlogifton, color, volatility, fufibility; and, laftly, may be rendered fimilar to the white calxes of antimony prepared by more expeditious proceffes, called *diaphoretic antimony*, and *bezoard mineral.*

Nitre detonates with this femi-metal, and accelerates more or lefs, according to the quantity of it employed, but always confiderably, thefe calcinations, as it does with all the imperfect metals.

Mineral acids diffolve regulus of antimony very difficultly. Aqua regia is the beft menftruum of it. Neverthelefs a very good combination of the marine acid with this metalic matter may be made by the procefs for butter of antimony. Sulphur acts upon regulus of antimony, with which it forms a compound not different from mineral antimony. Liver of fulphur diffolves it effectually, and forms with it an *antimoniated liver of fulphur*, more or lefs alkaline, from which a kermes mineral and golden fulphur of antimony may be obtained.

We only flightly mention here thefe preparations of regulus of antimony. As they are made moft commonly, and even moft conveniently, with antimony, they are more particularly defcribed under the article Antimony, and under the articles of the feveral names by which they are known.

Regulus of antimony is feldom found within the earth in any other ftate than mineralifed by fulphur, and in form of antimony. Mr. Anthony Swab mentions, in the Memoirs of the Swedifh Accademy for 1748, that he had found, in a mine near Salberg in Sweden, a regulus of antimony not mineralifed.

Regulus of antimony is eafily obtained pure and difengaged from fulphur, by the ordinary procefs for obtaining metallic matters from their ores, that is, by calcining them, and thus depriving them of their mineralifing fubftances, fulphur and arfenic, and afterwards by fufing the metallic earth with a matter proper to give it phlogifton. Thus, by fufing the grey calx of antimony, for inftance, with black flux or foap, we fhall obtain a fine regulus of antimony, as Kunckel has fhewn, and as Mr. Geoffroy afterwards practifed. But the ordinary method of making fmall quantities of the regulus in laboratories, and defcribed in books of chemiftry, is more expeditious, becaufe calcination is avoided. It confifts in mixing four parts of crude antimony with three parts of tartar and one part and a half of nitre; in detonating this mixture, by parts, in a large red-hot crucible; and afterwards by raifing the heat fo as to produce fufion. When the crucible is cold, it is to be broken, and at the bottom may be found a regulus of antimony lying under a faline fcoria, from which it is eafily feparated by the ftroke of a hammer, as has been faid under the word *antimony*.

The nitre added in this operation confumes quickly the largeft part of the fulphur of the antimony. The tartar is burnt and alkalifed. This alkali, mixed with a part of the alkali of the nitre, feizes a portion of the fulphur of antimony, with which it forms a liver of fulphur; and this liver diffolves in its turn a portion of the regulus of antimony, which confequently remains in the fcoria. The fcoria alfo contains a certain quantity of vitriolated tartar formed by the acid of the portion of fulphur, the phlogifton of which has been burnt

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during detonation, and by a part of the alkalis of nitre and of tartar. As tartar enters largely into this mixture, and as it contains much oil, a ſufficient quantity of phlogiſton remains (as the quantity of nitre uſed is but ſmall) to reduce the earth of the antimony to a metallic ſtate.

We may eaſily perceive that this fuſion of the ore of regulus of antimony, with intention to ſeparate from it the regulus, has no other advantage than that of being very expeditious, becauſe the calcination, which is long, is avoided. But it does not procure all the metallic matter of the ore, ſince a part of it always is combined with the liver of ſulphur in the ſcoria; and alſo as regulus of antimony is volatile, much of it is diſſipated in fumes during the detonation. This method, therefore, which without this inconvenience would be well adapted for obtaining at once a metal from a crude ore, is evidently unfit for the purpoſe of eſſay, in which caſe, great care muſt always be taken that no liver of ſulphur be formed during the operation. For this reaſon the ore muſt be deprived very accurately of all its ſulphur by torrefaction before it is fuſed. Some chemiſts even avoid the uſe of alkaline fluxes, as the black and white fluxes, in fuſions for eſſays of ores, becauſe a ſmall quantity of ſulphur frequently adheres ſtrongly to the ore, notwithſtanding the calcination; and this method is certainly the ſafeſt and moſt accurate. But when the preciſe quantity of metal contained in the ore is not required, we may conveniently uſe this fuſion of crude mineral with crude flux, as is uſually done for the obtaining of regulus of antimony in chemical laboratories.

Regulus of antimony is one of the moſt important metallic matters, becauſe it furniſhes ſome very powerful remedies. When taken in ſubſtance, it is emetic and purgative, but is uncertain in its effects, becauſe it only acts when it is diſſolved, or corroded by the ſubſtances it meets in the primæ viæ, and becauſe theſe ſolvents are very various, according to the nature of the aliments, and alſo to the variable ſtate of the temperament. When the uſe of antimony was firſt introduced, ſmall globules of the regulus were taken internally, which paſſed through the inteſtinal canal, and laſtly were thrown out of the body along with the evacuations which they occaſioned. As theſe globules or pills were neither diminiſhed nor altered ſenſibly after theſe operations, and as they were capable of ſerving an indefinite number of times, they were called *perpetual pills*. Cups alſo were made of the regulus of antimony, in which wine being left, acquired a purgative quality; but as the wine diſſolved more or leſs in proportion to the quantity of acid contained in it, and as wine is very various in this reſpect, hence the effects of this wine were not more certain than thoſe of the perpetual pills. Since the diſcovery of better antimonial preparations, theſe ancient remedies have been neglected. Their uncertainty, and even the dangerous accidents which they frequently occaſion, have undoubtedly contributed not a little to the oppoſition that many phyſicians, otherwiſe perſons of merit, made for a long time to the uſe of antimony, when it was firſt introduced into medicine. The famous quarrels excited concerning antimony are well known. On both ſides of this conteſt there were ſome reaſon and ſome error. They who rejected the uſe of antimony certainly erred in proſcribing a ſubſtance capable of furniſhing ſo excellent remedies; and the moſt zealous partiſans of it were too extravagant in their praiſes, at a time when its qualities and the methods of preparing it were not well known, and

when the effects of the antimonials then administered were so uncertain and dangerous.

Regulus of antimony is also useful in many arts. It enters into the compositions for metallic speculums of telescopes, and for printing types.

According to Mr. Geoffroy's table of affinities, it unites with metals in the following order. Iron, copper, silver, and lead; and according to Mr. Gellert, with zinc, iron, copper, tin, lead, silver, bismuth, gold.

DLXXXIX. REGULUS (MARTIAL) *of* ANTIMONY, *or* REGULUS *of* ANTIMONY PRECIPITATED *by* METALS. Regulus of antimony has much less affinity with sulphur than most other metallic matters, as iron, copper, tin, lead, silver, and bismuth. Accordingly, when crude antimony is fused with a sufficient quantity of any of these metals, the reguline part may be separated from the sulphur. A true precipitation is then made by the dry way. As iron, of all metals, has most affinity with sulphur, it is preferable to any other for the separation of regulus of antimony by this precipitation.

The process used for that purpose consists in making some horseshoe-nails white-hot in a crucible (these nails being soft iron and easily fusible with sulphur), to which is to be added twice their weight of crude antimony, and in procuring by a strong heat a fusion of the whole, after having covered the crucible. The iron which unites with the sulphur of the antimony is by its means perfectly fused; and, being rendered lighter than the reguline part of the antimony then deprived of sulphur, rises to the upper part of the melted mass, while the regulus sinks to the bottom.

If the fusion has been compleat, we shall find upon breaking the crucible, when cold, a fine regulus of antimony covered with a hard scoria, which is a combination of iron with the sulphur of antimony. The most essential point to be attended to in this operation is to give a sufficient heat for a perfect fusion; but as this heat must be very strong, most of the processes directed in books for the preparation of this regulus, order the addition of a quantity of nitre equal to a fifth part of the antimony employed, as soon as the fusion commences. This nitre detonates with the phlogiston of the substances contained in the mixture, its detonation makes it considerably more fluid, and this nitre, when alkalised, mixing with the scoria, forms a liver of sulphur, which dissolves a portion of the metals, and makes the scoria more fluid by giving to it a saline quality.

Lemery and many others direct, that the regulus should be afterwards fused thrice, and that in the first of these three fusions an eighth part of crude antimony, with the same quantity of nitre as in the former fusion, should be added, and the nitre only in the two latter fusions.

The crude antimony added in the second fusion is intended to carry off by means of its sulphur a part of the iron which may be united with the regulus, and the nitre which is to be added in each of the following fusions is intended to purify further the regulus from any remaining portion of sulphur. The intention then of all these preparations is only to obtain a pure regulus of antimony, which may be obtained otherwise much more easily. *See the preceding article.*

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DXC. REGULUS *of* ARSENIC. This is white arsenic, to which the properties of a semi-metal have been given, by combining it properly with a sufficient quantity of phlogiston.

Regulus of arsenic may be made by several methods. The process anciently used for this purpose consisted in mixing four parts of arsenic with two parts of black flux, one part of borax, and one part of filings of iron, or of copper and quickly fusing the mixture in a crucible. When the operation is finished a regulus of arsenic will be found at the bottom of the crucible, of a white livid color, and considerably solid. The iron and copper employed in this process are not intended, as in the operation for the martial regulus of antimony, to precipitate the arsenic, and to separate it from sulphur or any other substance; for the white arsenic is pure, and nothing is to be taken from it, but, on the contrary, the inflammable principle is to be added to reduce it to a regulus. The true use of these metals in the present operation is to unite with the regulus of arsenic, to give it more body, and to prevent its entire dissipation in vapors. Hence the addition of iron, while it procures these advantages, has the inconveniency of altering the purity of the regulus: for the metallic substance obtained is a regulus of arsenic allayed with iron. It may, however, be purified from the iron by sublimation in a close vessel; by which operation the regulised arsenical part, which is very volatile, is sublimed to the top of the vessel, and is separated from the iron, which, being of a fixed nature, remains at the bottom. We are not, however, very certain that in this kind of rectification, the regulus of arsenic does not carry along with it a certain quantity of iron, for in general a volatile substance raises along with it, in sublimation, a part of any fixed matter with which it happened to be united.

Mr. Brandt proposes another method, which we believe is preferable to that described. He directs that white arsenic should be mixed with soap. Instead of the soap, olive oil may be used, which I have found to succeed well. The mixture is to be put into a retort or glass matrass, and to be distilled or sublimed with a fire at first very moderate, and only sufficient to raise the oil. As the oils, which are not volatile, cannot be distilled but by a heat sufficient to burn and decompose them, the oil therefore which is mixed with the arsenic undergoes these alterations, and after having penetrated the arsenic thoroughly, is reduced to a coal. When no more oily vapors rise, we may then know that the oil is reduced to coal. Then the fire must be encreased, and the metallised arsenic will be soon sublimed to the upper part of the vessel, in the inside of which it will form a metallic crust. When no more sublimes, the vessel is to be broken, and the adhering crust of regulus of arsenic is to be separated. The regulus obtained by this first operation is not generally perfect, or not entirely so, as a part of it is always overcharged with fuliginous matter, and another part has not enough of phlogiston, which latter part adheres to the inner surface of the crust, and forms grey or brown crystals. This sublimate must then be mixed with a less quantity of oil, and sublimed a second time like the first; and even, to obtain as good a regulus as may be made, a third sublimation in a close vessel, and without oil, is necessary. During this operation, the oil which rises is more fetid than any other empyreumatic oil, and is almost insupportable. This smell certainly proceeds from the arsenic, the smell of which is exceedingly strong and disagreeable, when it is heated.

Regulus of arsenic, made by the method I have described, and which I consider as the only one which is pure, has all the properties of a semi-metal. It has metallic gravity, opacity, and lustre. Its color is white and livid, it tarnishes in the air, is very brittle, but much more volatile than any other semi-metal. It easily loses its inflammable principle, when sublimed in vessels into which the air has access; the sublimate having the appearance of grey flowers, which by repeated sublimations become entirely white, and similar to white crystalline arsenic.

When regulus of arsenic is heated quickly and strongly in open air, as under a muffle, it burns with a white or bluish flame, and dissipates in a thick fume, which has a very fetid smell, like that of garlic.

Regulus of arsenic may be combined with acids and most metals. As white arsenic also can unite with these substances, we refer to that article. We shall only observe here, that, according to Mr. Brandt, in the Swedish Memoirs, the regulus of arsenic cannot be united with mercury. Altho' the phenomena exhibited by white arsenic and regulus of arsenic in solutions and allays are probably the same, yet an accurate comparison of these would deserve notice, especially if the regulus employed were well made; for some difference must proceed from the greater or less quantity of phlogiston with which it is united. *See* ARSENIC.

DXCI. REGULUS *of* COBALT. Regulus of cobalt is a semi metal lately discovered, and not yet perfectly well known. It receives its name from cobalt, because it can only be extracted from the mineral properly so called.

The process by which this semi-metal is obtained is similar to those generally used for the extraction of metals from their ores. The cobalt must be thoroughly torrefied to deprive it of all the sulphur and arsenic it contains, and the unmetallic earthy and stoney matters must be separated by washing. The cobalt thus prepared is then to be mixed with double or triple its quantity of black flux, and a little decrepitated sea-salt, and must be fused either in a forge or in a hot furnace. For this ore is very difficult of fusion.

When the fusion has been well made, we find upon breaking the crucible, after it has cooled, a metallic regulus covered with a scoria of a deep blue color. The regulus is of a white metallic color. The surface of its fracture is close and small grained. This semi-metal is hard, but brittle. When the fusion has been well made, its surface appears to be carved with many convex threads which cross each other diversely. As almost all cobalts contain also bismuth, and even as much as of the regulus itself, this bismuth is reduced by the same operation, and precipitated in the same manner as the regulus of cobalt; for although these two metals are frequently mixed in the same mineral, that is, in cobalt, they are incapable of uniting together, and are always found distinct and separate from one another when they are melted together. At the bottom of the crucible then we find both regulus of cobalt and bismuth. The latter, having a greater specific gravity, is found under the former. They may be separated from each other by the blow of a hammer. Bismuth may be easily distinguished from the regulus of cobalt, not only from its situation in the crucible, but also by the large shining facets which appear in its fracture, and which are very different from the close, ash-colored grain of regulus of cobalt.

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This ſemi-metal is more difficult of fuſion than any other, is leſs eaſily calcinable, and much leſs volatile. Its calx is grey, and more or leſs brown, and when fuſed with vitrifiable matters, it changes into a beautiful blue glaſs called *ſmalt*. This calx then is one of thoſe which preſerve always a part of their inflammable principle. It is ſoluble in acids as the regulus is. This regulus is ſoluble in vitriolic, marine, nitrous acids, and in aqua regia, to all which it communicates colors. The ſolution in vitriolic acid is reddiſh; the ſolution in marine acid is of a fine bluiſh-green when hot, and its color is almoſt totally effaced when cold, but is eaſily recoverable by heating it, without being obliged to uncork the bottle containing it. This ſolution of the calx or regulus of cobalt is the baſis of the ſympathetic ink, for without marine acid this ink cannot be made. *See* INK (SYMPATHETIC).

All the ſolutions of regulus of cobalt may be precipitated by alkalis, and theſe precipitates are blue, which color they retain when vitrified with the ſtrongeſt fire.

Not only ſympathetic ink, but alſo regulus of cobalt, may be made from the *zaffre* commonly ſold, which is nothing elſe than the calx of regulus of cobalt mixed with more or leſs pulveriſed flints. For this purpoſe we muſt ſeparate as well as we can the powder of flints from it by waſhing, as Mr. Beaumé does, and then reduce it with black flux and ſea-ſalt.

Regulus of cobalt ſeems incapable of uniting with ſulphur, but it eaſily unites with liver of ſulphur, and the union it forms is ſo intimate, that Mr. Beaumé could not ſeparate theſe two ſubſtances, otherwiſe than by precipitation with an acid.

Many curious and intereſting remarks are ſtill to be diſcovered concerning this ſingular ſemi-metal, and we may hope to receive further information from the endeavors of chemiſts who have undertaken the examination of it. Mr. Beaumé particularly has made conſiderable experiments on this ſubject, part of which he communicates to the public in his Courſe of Chemiſtry. All the new remarks in this article are from him. We wiſh that this able chemiſt would publiſh the numerous experiments he has made on this ſubject. *See* COBALT, INK (SYMPATHETIC), AZURE, SAFFRE, *and* SMALT.

DXCII. R E S I N. The name *reſin* in its moſt general ſenſe might be applied to all ſolid or concrete oily ſubſtances, not only thoſe particularly called *reſins*, as *maſtich*, *ſandarach*, *white pitch*, &c. but alſo to wax, butter, fat, &c. But theſe concrete oily matters differ ſo much from each other, that they ought to be more particularly diſtinguiſhed.

Firſt, we may obſerve, that every ſolid oily ſubſtance owes its conſiſtence to a ſaline, and eſpecially to an acid matter; for we know that a liquid oil may be rendered thick by the addition of an acid, in proportion to the quantity of acid, and intimacy of combination. We alſo know, that by decompoſing concrete oils by diſtillation, we obtain a quantity of acid ſo much greater, or ſo much ſtronger, as this oil is thick or more ſolid; or at leaſt, that the quantity of liquid oil obtained by this diſtillation is proportionable to the quantity of acid ſeparated.

But

But all concrete oils may be naturally combined with a ſufficient quantity of acid, to give it this conſiſtence, in two manners; for either they have received originally from nature a ſufficient quantity of acid, or elſe, being formed originally fluid, they have loſt by evaporation the part which is the moſt thin, moſt volatile, and leaſt charged with acid, or leaſt perfectly combined with acid; by which the proportion of well combined acid is more and more encreaſed in the portion which is not evaporated, and which is therefore rendered thicker.

According to this diſtinction, concrete oils are naturally divided into two claſſes, the former comprehending thoſe which are always found in a ſolid ſtate, as wax, butter, and the ſat of animals, and the latter comprehending the thickened or conſolidated reſiduums of oils, which, from a liquid ſtate, have become concrete by the diſſipation and evaporation of their moſt fluid part. This ſecond claſs includes all concrete oils, to which the name of reſins has been applied. The properties of all concrete oils of the former claſs ſhew inconteſtably that theſe oils, or oily concretions, are of the kind of oils which are moſt ſweet, moſt unctuous, leaſt inflammable, and leaſt volatile. Accordingly, all theſe matters reſemble each other eſſentially, and only differ from one another by their greater or leſs ſolidity: but the reſins or concrete oils of the ſecond claſs are very different from one another, ſome of them having a ſtrong aromatic ſmell, and diſſolving eaſily and entirely in ſpirit of wine, and others having little or no ſmell, at leaſt when cold, and being totally unſoluble in ſpirit of wine; ſuch as *gum-copal* Theſe properties ſo different amongſt ſubſtances, confounded under one general name, ſhew that the liquid oils whence they were formed were eſſentially different. The former reſins ought to be conſidered as the reſiduums of eſſential oils and natural balſams, ſince they evidently retain the principal properties of theſe. The latter can only be the reſiduums of certain oils not volatile, unſoluble in ſpirit of wine, but capable of becoming rancid, thick, and dry; as oil of linſeed, hemp, nuts, &c. for theſe oils, kept a long time in a dry place, in open ſhallow veſſels, become concrete, tranſparent, deprived of all ſmell, and unſoluble in ſpirit of wine, like the reſin called *gum-copal*. Natural reſins of this latter claſs are much rarer than thoſe of the former, becauſe more vegetables have a ſuperabundant eſſential oil than a ſuperabundance of drying oil, which is not volatile; or, at leaſt, this ſecond kind of oil is leſs eaſily evaporable than the former.

Reſinous matters have not been ſufficiently examined. We might probably find many of them ſimilar to copal, and alſo others, which, proceeding from the two kinds of oils above deſcribed, mixed and evaporated together, would partake at the ſame time of the two kinds of reſins reſulting from theſe, and would hold a ſimilar relation to the two kinds of reſins which gum-reſins hold to gums and reſins. Amber and other ſolid bitumens, which alſo are oily concrete matters, unſoluble in ſpirit of wine, and evidently of vegetable origin, are probably formed by oils not volatile, thickened and hardened by age, or by intimate combination with mineral acids.

Reſins, being only thickened balſams, are collected, as theſe balſams are, upon trees and plants from which they have exſuded. Several of them are obtained by art. Such is the *black pitch*, which is obtained by making it melt

and

and exsude, by means of heat, from firs, pines, and other trees of this kind, which contain large quantities of it. Such also are the resins of jalap, scammony, and turpeth, which are obtained for medicinal uses, by digesting the vegetables containing them previously well dried, in spirit of wine, from which they are afterwards separated by adding a large quantity of water.

Resins are employed for many purposes. The cheapest kinds are used for torches, and to cover the outsides of ships and boats. The fine, transparent resins compose varnishes. Many of them are employed medicinally; either externally, as, for instance, those which enter into the composition of ointments and plasters; or internally, as the resins of scammony, jalap, turpeth, which are purgative. Other resins, the smell of which is agreeable, as, for instance, benjamin and storax, are employed as perfumes. *See the articles* BALSAMS, BITUMENS, OILS, *and* GUM-RESINS. *See also the Dictionary of Natural History for the particular detail of the different kinds of resins and their uses.*

DXCIII. R E T O R T. Retorts are vessels employed for many distillations, and most frequently for those which require a degree of heat superior to that of boiling water. This vessel is a kind of bottle with a long neck so bent, that it makes with the belly of the retort an angle of about sixty degrees. From this form they have probably been named *retorts*. The most capacious part of the retort is called its *belly*. Its upper part is called the *arch* or *roof of the retort*, and the bent part is the *neck*. *See* PLATE I. *Fig.* 1. *and* 2.

Retorts differ in form and materials: their bellies are generally round: some of them are oblong and shaped like a cucurbit: these are called *English retorts*. They are preferable for the distillation of matters which are subject to swell and to pass into the receiver before they be decomposed.

A retort which has a little hole pierced in its roof is called a *tubulated retort*. This hole must be capable of being exactly closed with a stopper of proper materials. Retorts of this kind are employed in distillations, where some matter must be introduced into the retort after the receiver is joined to it, as in the distillation of smoking marine acid, and in the operations for procuring the several kinds of *clyssus*.

If the retort be well made, the above-mentioned inclination of its neck must be most favorable to distillation. When the neck is too much inclined, the receiver cannot be conveniently luted to it, and is also by this form brought too near the furnace. If the neck be too little inclined, the vapors or liquors which rise in distillation can scarcely flow into the receiver from want of sufficient descent, and only circulate in the belly of the retort. Retorts, when too strait in their bending, are very faulty. This form must be an impediment to distillation: the passage therefore from the belly to the neck of the retort must be free and wide, and gradually diminishing to the extremity of the neck or the mouth of the retort.

Retorts of different materials are used in chemical operations, of common glass, crystal-glass, stone-ware, iron. Retorts of glass are used for all operations which require a less heat than is sufficient for their fusion. Earthen retorts are necessary where great heat is requisite, as in the preparation of phosphorus. Iron retorts are not much used, as they can only serve for the distillation

lation of substances which cannot act upon this metal, and as these substances are few in number. They can seldom be employed but for the distillation of mercury and of animal matters.

DXCIV. REVERBERATORY. See FURNACE.

DXCV. REVIVIFICATION. See REDUCTION.

DXCVI. RHUBARB. (*n*)

DXCVII. RISIGAL. The same as REALGAR.

DXCVIII. ROASTING *of* ORES. See SMELTING *of* ORES.

DXCIX. ROSEMARY. (*o*)

DC. RUBIN *of* ANTIMONY. This is a kind of liver of antimony, made with equal parts of nitre and crude antimony detonated together, to which is afterwards added an equal part of common salt; but as the addition of the salt is useless, the preparation is not now employed. It is also called *magnesia opalina*. See ANTIMONY *and* LIVER *of* ANTIMONY.

DCI. RUBY (ARSENICAL). This preparation is red realgar, to which, by fusion and cooling, a transparency is given which makes it resemble a ruby; in which respect only it differs from realgar. See REALGAR.

(*n*) RHUBARB. An ounce of Rhubarb, reduced into gross powder, yielded with highly rectified spirit of wine three drams of extract, and afterwards with water two drams, two scruples and a half: the residuum weighed two drams twelve grains. By applying water first to another ounce, five drams, two scruples and a half of extract were obtained, and of the residuum five grains only were soluble in spirit of wine. Rhubarb appears from these experiments to contain much more gummy or mucilaginous than resinous matter; and hence spirituous tinctures of it are not precipitated or rendered milky by addition of water, like the tinctures of most other vegetables.

The yellow color of rhubarb is remarkably less destructible than many other vegetable yellows. Aqua fortis and other acids, which destroy the color of saffron, turmeric, &c. make no change in that of rhubarb, or at most render it only turbid. Volatile spirits heighten the color, and incline it to red. Fixed alkaline salts have this effect in a greater degree. Solutions of green vitriol and other chalybeate liquors, change the color of infusions of rhubarb to an inky blackness; a mark that this root is possessed of an astringent quality. The spirituous extract does not purge, although the extract made by water after spirit does, as if its purgative quality resided chiefly in a combination of gummy and saline matter. *Neuman*.

(*o*) ROSEMARY. The only active principle in this plant is the essential oil. The gummy extract, divested of the oil, has no remarkable taste any more than smell. The resinous extract retains a considerable part of the flavor of the herb, and of the essential oil. Its fragrance is communicated by infusion or by distillation to spirit or to water. Vinous spirit, impregnated by distillation with the flavor of rosemary, is called *Hungary-water*. The flowers of this plant contain little or no smell, and no oil could be collected from the distilled water; but from forty-eight ounces of leaves, [illegible] and half a scruple of oil were obtained by distillation. Tournefort observes, that those sorts of rosemary, which produce neither flowers nor seeds, and which have very hard shrubby stalks [illegible] strongly like [illegible] ling a large q[illegible] taining their oil a [illegible] phor. *Neuman*.

DCII.

DCII. R U S T. This name is particularly applicable to the earth of iron decomposed by the action of water and of air; but it may be given to the earth of any other metal capable of such decomposition, as copper, and all other metallic matters, excepting the perfect metals. Thus verdegrise might be called the rust of copper. The kind of *ceruss* formed upon lead, exposed to a humid air, may be called *rust of lead*, &c. *See the articles of the several metallic matters.*

S.

DCIII. SAFFRE. *See* ZAFFRE.

DCIV. SAFFRON. (*p*).

DCV. SAFFRON *of* IRON. Chemiſts have given the name *ſaffron* to many preparations which have a yellow color, like that of ſaffron, and particularly to the earth or ruſt of iron which has that color.

As iron may be deprived of its phlogiſton by the combined action of air and of water, by that of air and fire, and, laſtly, by acids, different names have been given to ſaffrons of Mars, or ferruginous earths prepared by theſe ſeveral agents. The ruſt of iron made by humid air is called *martial ſaffron prepared with dew*, or *aperitive ſaffron of Mars.* Iron, dephlogiſticated by vitriolic acid or ſulphur, is alſo called *aperitive ſaffron of Mars.* Laſtly, that which is reduced into a calx by the action of fire, is called *aſtringent ſaffron of Mars. See, for the medicinal virtues of theſe preparations of iron, the articles* ETHIOPS MARTIAL *and* IRON.

As the ſaffrons of iron acquire different ſhades of red and orange colors, which they preſerve when melted with very fuſible vitrified matters, they are employed for painting on enamel, on pottery, porcelain, and for giving color to glaſs, or imitations of precious ſtones.

(*p*) SAFFRON. Both water and ſpirit extract the color and virtue of ſaffron. The former liquor improves the ſmell and heightens the color, whilſt the ſpirit ſeems rather to weaken both. By drying two ounces and a half of the beſt ſaffron in the heat of a water-bath, half an ounce of liquor was obtained, which had an exceeding ſtrong ſmell, but had not the appearance of oil. This is the active part of the ſaffron, which diſorders the head and ſenſes. Six drams of extract were obtained from an ounce of dried ſaffron by means of water, and five drams and one ſcruple were obtained from another ounce by means of ſpirit. Rectified ſpirit acquired no ſmell or taſte by diſtillation from dried ſaffron; but water being thus diſtilled acquired a ſtrong ſmell. *Newton.*

DCVI.

DCVI. SAFFRON *of* METALS. Saffron of metals is the metallic earth of antimony, half deprived of its sulphur and phlogiston by detonation of crude antimony with nitre, and afterwards well washed; or it is liver of antimony deprived of all saline matter by a sufficient washing. This preparation is a violent and uncertain emetic, not used by prudent physicians. *See* LIVER *of* ANTIMONY, *and* TARTAR (EMETIC).

DCVII. SALMIAC. This word is an abridgement used by some for sal ammoniac. *See* AMMONIAC (SAL).

DCVIII. SALT. The word salt, which is synonimous with saline matter or saline substances, when taken in its most general sense, is of all chemical terms that which is applicable to the greatest number of individuals. In fact, the number of different bodies, which have what chemists call a saline character, or which possess the principal saline properties, is so great that they are very far from being all known, as we shall afterwards see.

The essential properties of all matter, which ought to be considered as saline, are, to affect the sense of taste, to be soluble in water, and to have all the principal qualities, as gravity and fixity, in an intermediate degree betwixt those of water and of pure earth.

If we attend a little to the principal properties of the several bodies which are considered as salts or saline substances, we shall easily find that they do not all possess in the same degree the essential saline qualities that we have described. We shall see that some salts possess these qualities in the highest degree, while in others they are so weak and indistinct, that in many of them they can scarcely be discovered; and this diminution of the saline properties is so considerable in many compound bodies, that we may affirm that the limits which separate saline matters from others that are not saline, are unknown, indeterminate, and perhaps incapable of being determined.

We are certain, on the other side, that the saline substances whose properties are most distinct and strong, such, for instance, as the mineral acids, have great power over many other substances which have not a saline property; to which, by being combined together, they communicate more or less of their saline properties; or rather with which they form compounds, in which the saline properties are more or less sensible. Since experience shews that these saline compounds may be decomposed, so that the substance, which is not saline, shall be separated in its former state from the saline matter, which also shall recover the saline properties in the same force which it had before this union, we may from thence conclude;

First, that among the infinite multitude of bodies in which we may perceive saline properties, a very great number are composed of a substance essentially saline, and of one or more other substances not saline.

Secondly, that we ought to distinguish well substances which essentially possess saline properties from those which, not possessing any such properties themselves, are only capable of receiving more or less of them by uniting with substances of the former kind.

Thirdly, as the number of matters not saline which are capable of acquiring a saline character, or rather of forming compounds more or less saline by their union with substances essentially saline, is very great, the number of these last

muſt be very ſmall, in compariſon of the number of compounds in which ſaline properties are perceptible.

To give ſome explanation of this extenſive ſubject, we muſt begin by determining preciſely what ſubſtances eſſentially ſaline are, and by aſſigning a character which can diſtinguiſh them from thoſe, which, without containing any thing ſaline, may nevertheleſs make part of ſalts, by the union they are capable of contracting with the former. Theſe characters are the following:

All thoſe ſubſtances ought to be conſidered as eſſentially ſaline which have not only the characteriſtic properties of ſalts, as taſte and perfect miſcibility with water, in an eminent degree, but which alſo when diſengaged can communicate theſe properties, at leaſt in part, to other ſubſtances which have them not, by combining with theſe latter, from which, when afterwards ſeparated, they reſume their former ſtate and peculiar ſaline characters.

All acids and alkalis, mineral, vegetable, or animal, fixed or volatile, fluid or concrete, muſt be conſidered as ſubſtances eſſentially ſaline. Each of theſe bodies has the properties we have mentioned. Some other ſubſtances have not the properties of acids or of alkalis very diſtinctly; but as they have the properties of ſalts in general, and are capable of acting as acids, and of communicating ſaline properties to the compounds into which they enter, they may therefore be conſidered as ſubſtances eſſentially ſaline. Such are *arſenic* and *ſedative ſalt.*

But if we reflect a little on the particular properties of each of the ſubſtances which ſeem to be eſſentially ſaline, we ſhall obſerve that they do not all poſſeſs theſe properties in the ſame degree. How great the difference is in this reſpect betwixt pure, concentrated vitriolic acid and the acid of tartar! They can ſcarcely be known to be ſubſtances of the ſame kind. The taſte ſimply acidulous of cream of tartar, its ſtate of conſtant cryſtallization and dryneſs, its little ſolubility in water, laſtly, the weakneſs of the adheſion which it contracts with all the ſubſtances with which it can unite, cannot be compared with the ſtrong and corroſive taſte of vitriolic acid, with the activity of its ſeizing moiſture, with the ſurprizing heat occaſioned by its mixture with water, laſtly, with the extreme force that keeps this body united to all the bodies with which it is capable of combining. The ſlighteſt view of the other ſubſtances eſſentially ſaline is ſufficient to ſhow that they differ much from each other, particularly in their degree of ſtrength; in a word, that they do not poſſeſs the ſaline properties in the ſame degree.

Theſe are the conſiderations which have undoubtedly determined the greateſt chemiſts, particularly Stahl, to believe that the number of ſubſtances truly and eſſentially ſaline is very ſmall, and even that only one ſaline principle exiſts, which by the intimate union it is capable of contracting with ſeveral other ſubſtances, conſtitutes a certain number of matters which poſſeſs the ſaline properties in a degree ſufficiently ſtrong to preſerve theſe properties more or leſs in their ſeveral combinations with other matters that are not ſaline, and to recover them entirely when ſeparated from theſe combinations; ſo that as they do not themſelves undergo any decompoſition, and as they always appear again with the ſame properties after having been combined and ſeparated, they ſeem to be ſimple matters, eſſentially ſaline, although they really are compounds of

ſeveral

several bodies, not saline, united intimately with one only saline principle, which is universal and always the same.

According to this notion, which is grand and perfectly analogous to the plan which nature seems constantly to pursue in the different orders of compounds, the question is to discover which is the most simple of all saline substances, and is the principle of all others. The best, and perhaps the only, method of determining in a question of this nature, is to compare together the several saline substances, and to consider that as the most simple of all, which possesses the saline properties in the most eminent degree, and which also appears upon all occasions to be least susceptible of decomposition or alteration; for all chemistry shews us, that these are the characters of the most simple bodies, which are capable of becoming principles of more compound bodies: but when we examine all the saline matters under this point of view, we shall soon easily discover that we must begin by excluding all the saline matters called *neutral salts*; for any of these salts may be decomposed by ordinary chemical operations; and these decompositions show that many of them are composed of two simpler saline substances, one of which is called *acid*, and the other *alkali*; also, acids and alkalis are not in general so easily altered as neutral salts. In the classes therefore of these two saline substances, we must search for that which is the most pure and simple of all.

If we continue this inquiry upon the same principles, and compare together the saline properties of the purest and strongest acids and alkalis, we shall easily be convinced that the saline properties are stronger and more distinct in acids than in alkalis, since the former are more active, more dissolving, more adhering to the bodies dissolved, more deliquescent, &c. and also, that in the several operations of chemistry, alkalis fixed and volatile appear to be more susceptible of alteration and decomposition than acids. Amongst acids, therefore, we must search for the strongest and simplest saline matter.

Lastly, when we examine in the same manner, and compare together all the substances which have the principal properties of acids, and which are called acids, we shall clearly perceive that those which are truly vegetable and animal, that is, in the combination of which oil enters, are infinitely more weak and susceptible of alteration than acids deprived of all oil, which we call mineral acids; amongst which, the vitriolic will be easily discovered to be the strongest and most unalterable, and consequently of all bodies which have saline properties, the purest, simplest, and the most sensibly and essentially a salt.

Such considerations have undoubtedly induced the most profound chemists, and especially the illustrious Stahl, to consider this acid as the purest and simplest of all saline matters; and indeed all who are capable of reflecting on the greatest and most important phenomena of chemistry, will consider this proposition as a demonstrated truth. But Stahl carries this notion still farther. From his writings, and the whole of his doctrine, we may infer, first, "That "he considers the vitriolic acid as the only substance essentially saline; as the "only saline principle, which, by uniting more or less intimately with other "substances that are not saline, is capable of forming an innumerable multi-"tude of the other saline matters which nature and art shew to us; and,

"secondly, that this saline principle is a secondary principle, composed only of "the intimate union of two primary principles, *water* and *earth*."

Every true chemist will easily discover that this grand idea is capable of comprehending by its generality, and of connecting together, all the phenomena exhibited by saline substances. But we must at the same time acknowledge, that when we examine the proofs upon which it is founded, although it has a great appearance of truth by its consistency with the principles of chemistry, and with many phenomena, yet it is not supported by a sufficient number of facts and experiments to ascertain its truth.

We might here examine what degree of probability ought to be granted to this theory of salts, but this could not be properly accomplished without entering into long details, and penetrating into the depths of chemistry; in a word, without making a full and compleat treatise, which cannot be admitted in a work of this nature. We are therefore obliged to relate only what is most essential to be known concerning this grand hypothesis. We may perceive at once, that the former of these propositions, upon which is founded the theory which we mentioned, cannot be demonstrated, unless it be previously proved that every saline matter, excepting pure vitriolic acid, is nothing but this same acid differently modified, the primary properties of which are more or less altered or disguised by the union contracted with other substances. But we confess, that chemists are not capable of proving decisively this opinion; which, however, will appear very probable from the following reflections.

First, of all saline matters known, none is so strong, so unalterable, so eminently possessed of saline properties, as *vitriolic acid*.

Secondly, amongst the other saline substances, those which appear most active, and most simple, as *nitrous* and *marine acids*, are at the same time those, whose properties most resemble the properties of vitriolic acid.

Thirdly, we may give to vitriolic acid many of the characteristic properties of nitrous acid, by combining it in a certain manner with the inflammable principle, as we see in the volatile sulphureous acid. *See* ACID (VOLATILE SULPHUREOUS), *and* ACID (NITROUS): and even, according to an experiment of Mr. Piech, related in a Memoir concerning the origin of nitre, which gained the prize of the Academy of Berlin, vitriolic acid, mixed with vegetable and animal matters susceptible of fermentation, is really transformed into a nitrous acid by the putrefaction of these matters.

Fourthly, the marine acid, altho' its principles are less known than those of the nitrous acid, may be approximated to the character of vitriolic and nitrous acids by certain methods. This acid, after it has been treated with tin and other metallic matters, is capable of forming ether with spirit of wine, as vitriolic acid does, which it cannot do in its natural state; and when iron is dissolved in it, it seems to be approximated to the nature of nitrous acid. Reciprocally, the approximation of vitriolic acid to the character of marine acid seems not impossible. Having once distilled very pure vitriolic acid upon a considerable quantity of white arsenic, I was struck with a strong smell like that of marine acid, which was not either that of arsenic or of vitriolic acid; for this has no smell, when it is pure.

Fifthly, oily vegetable acids become so much stronger, and more similar to vitriolic acid, as they are more perfectly deprived of their oily principle, by combining

combining them with alkalis, earths, or metals, and afterwards by separating them from these substances, by distillation, and especially by frequently repeating these operations. They might perhaps be reduced to a pure vitriolic acid, by continuing sufficiently this method: and reciprocally, vitriolic and nitrous acids weakened by water, and treated with much oily matters, or still better with spirit of wine, acquire the characters of vegetable acids. We may see a remarkable instance of this in Mr. Pott's *Dissertation de Acido Nitri Vinoso.*

Sixthly, the properties of fixed alkalis seem to be very different from those of acids in general, and consequently of vitriolic acid. Yet if we consider that a large quantity of earth enters their composition; that much of it may be separated by repeated solutions and calcinations; and also that by depriving these saline substances of their earthy principle, they become less fixed, more deliquescent, and, in a word, more similar to vitriolic acid in this respect; we shall not think it improbable, that fixed alkalis owe their saline properties to a saline principle of the nature of vitriolic acid, but much disguised by the quantity of earth, and probably of inflammable principle, to which it is united in these combinations. The properties of volatile alkalis, and the transformation of fixed alkali or of its materials into volatile alkali in putrefaction and in several distillations, seem to shew sufficiently that they are matters essentially saline, as fixed alkalis are, and that their volatility which distinguishes them proceeds from their containing a less quantity of earth, but more attenuated, and a portion of very subtle and volatile oil, which enters their composition.

Besides these principal facts, there are many others, too numerous to be even slightly mentioned here: they may be found scattered in the works of chemists, particularly of Stahl. But persons who would collect and compare all the experiments relating to this subject, ought to know, that many of them are not sufficiently ascertained, and that perhaps a greater number of them have not been sufficiently prosecuted, and are, properly speaking, only begun. We must even acknowledge, that many of those experiments which we have mentioned have not been sufficiently prosecuted. *See all the articles of acids and alkalis.*

The second fundamental proposition of the theory of salts, namely, "that "the vitriolic acid is compounded of only the aqueous and earthy principles," is, like the first, supported by many facts which give it a degree of probability, but which do not amount to a compleat demonstration. This proposition may be supported by the following considerations.

First, experience constantly shews, that the properties of compound bodies are always the result of those of the component parts of these bodies, or rather they are the properties of these component bodies modified by one another.

Thus, if a body be composed of two principles, one of which is fixed and the other volatile, it will have a less degree of fixity than the former, and a less volatility than the latter. If it be composed of two principles, one of which is specifically heavier than the other, its specific gravity will be greater than that of one of them, and less than that of the other. The same observation is applicable to all the other essential properties, excepting those which destroy each other, as, for instance, the tendency to combination, or the dissolving power; for these latter properties are weakened so much more in the compounds, as their principles are more strongly united, and in more just proportion.

We

We observe nevertheless, that the properties of compound bodies are not always exactly intermediate betwixt the properties of the component bodies; for, to produce this mean, the quantities of each of the component parts must be equal, which is the case in few or no compounds.

Besides, some particular circumstances in the manner in which the principles unite with one another, contribute more or less to alter the result of the combined properties; for instance, experience shews, that when several bodies, particularly metals, are united together, the specific gravities of which are well known, the allay formed by such union has not the precise specific gravity which ought to result from the proportion of the allayed substances; but that in some allays it is greater, and in others less. But we are certain, on the other side, that these differences are too inconsiderable to prevent our distinguishing the properties of the principles in the compounds which they form, especially when they have very different properties.

These things being premised, when we examine well the properties of vitriolic acid, we shall easily find that they partake of the properties of the aqueous and of the earthy principles.

First, when this acid is as pure as we can have it, it is like the purest water and the purest vitrifiable earths, free from color or smell, and perfectly transparent.

Secondly, although we cannot deprive the vitriolic acid of all the water superabundant to its saline essence, and therefore its precise specific gravity has not been determined, we know that when it is well concentrated, it is more than twice as heavy as pure water, and much less heavy than any earthy substance.

Thirdly, this acid is much less fixed than any pure earth, since, however well it may be concentrated, it may always be entirely distilled; for which purpose, a much stronger degree of heat is requisite than for the distillation of pure water.

Fourthly, we do not know the degree of solidity of vitriolic acid, or the *adhesion of aggregation* which its integrant parts have one to another, because for this purpose the vitriolic acid ought to be deprived of all superabundant water; but if we judge of it by the solid consistence of this acid when highly concentrated, as we see from the vitriolic acid called *glacial*, the integrant parts of this acid seem susceptible of a much stronger adhesion than those of pure water, but much less than those of earth, as we see from the instances of hard stones.

Fifthly, the union which this acid contracts with water and with earths, shews that these substances enter into its composition: for we know that all compounds are disposed to unite superabundantly with the principles which compose them. All these properties of vitriolic acid, which so sensibly partake, and much more than any other acid, of the properties of earth and of water, are sufficient to induce us to believe that it is composed of these two principles; but it has one very eminent property, which is common with it to neither water nor pure earth, which is, its violent and corrosive taste. This property is sufficient to raise doubts, if we could not explain it from principles which seem certain and general, relating to the combination of bodies. We shall here summarily recapitulate them, although we have spoken of them in several

articles

articles of this work, particularly at the words Affinity, Aggregation, Solution, Composition, Gravity, Saturation.

We observe then concerning the property now in question, that is, of taste in general, that it can only be considered as an irritation made upon the organs of taste by sapid bodies: and if we reflect attentively upon it, we shall be convinced that no substance that is not impressed by some impulse, can irritate or agitate our sensible organs, but by a peculiar force of its integrant parts, or by their tendency to combination, that is, by their dissolving power. According to this notion, the taste of bodies, or the impression made upon our sensible organs by their tendency to combination, or by their dissolving power, are the same property; and we see accordingly, that every solvent has a taste which is so much more strong, as its dissolving power is greater; that those whose taste is so violent that it amounts to acrimony, corrosion, and causticity, when applied to any other of the sensible parts of our body besides the organs of taste, excite in them itching and pain.

This being premised, the question is, how earth, in which we perceive no taste nor dissolving power, and water, which has but a very weak dissolving power, and little or no taste, should form by their combination a substance, such as the vitriolic acid is, powerfully corrosive and solvent?

To conceive this, let us consider first that every part of matter has a power by which it combines, or tends to combine with other parts of matter. Secondly, that this force, the effects of which are perceptible, in chemical operations, only among the very small molecules, or the integrant and constituent parts of bodies, seems proportionable to the density or specific gravity of these parts. Thirdly, that this same force is limited in every integrant molecule of matter; that if we consider this force as not satisfied, and consequently as a simple tendency to combination, it is the greatest possible in an integrant molecule of matter perfectly insulated, or attached to nothing, and is the smallest possible, or none, when it is satisfied by its intimate combination with other parts capable of exhausting all its action; its tendency is then changed into adhesion.

Hence we may infer, that the integrant parts of the earthy principle have essentially, and, like all the other parts of matter, a force of tendency to union, or of cohesion in union, according to their condition; that as this earthy principle has a much more considerable density or specific gravity than all other simple bodies that we know, we may probably presume that its primary integrant molecules have a more considerable force of tendency to union, in the same proportion, than the integrant parts of other principles; that consequently when they cohere together, and form an aggregate, their aggregation must also be stronger and firmer than that of any other body. Accordingly we see that the purest earthy substances, whose parts are united and form masses, such as, for instance, the stones called vitrifiable, are the hardest bodies in nature. We are no less certain, that as the tendency of the parts of matter to unite is so much less evident as it is more exhausted and satisfied in the aggregation, the parts of the earthy principle being capable of exhausting mutually all their tendency to union, we may thence infer, that every sensible mass of pure earthy matter must appear deprived of any dissolving power, of taste, in a word, of tendency to union, from the firmness of its aggregation. But we may also infer, that when these primary integrant parts of the earthy principle are not

united

united together in aggregation, then, resuming all the activity and tendency to union which are essential to them, they must be the strongest and most powerful of all solvents.

These being premised, if we suppose again, with Stahl and the best chemists, that in the combination of the saline principle or of vitriolic acid, the parts of the earthy principle are united, not with each other, as in the earthy aggregation, but with the primary parts of the aqueous principle, each to each, we may then easily conceive that the primary integrant parts of the water, having essentially much less tendency to combination than those of earth, the tendency of these latter to union will not be exhausted, but satisfied only partly, by their combination with the former, and that consequently a compound must result, the integrant parts of which will have a strong dissolving power, as vitriolic acid is.

We may see from hence how much mistaken chemists are, who, considering earth only in its aggregation, or rather not attending to this state, and not distinguishing it from that state in which the parts of this same earth are so separated from each other by the interposition of another body, that they cannot touch or cohere together, have considered the earthy principle as a substance without force or action, and have very improperly called that a *passive principle*, which of all others is the strongest, most active, and most powerful.

However this general theory of salts may conform with the most important phenomena of chemistry, we must acknowledge that it can only be proposed as a systematical opinion, till it be evidently demonstrated by the decisive means employed in chemical demonstrations, namely, by decomposition and recomposition: thus, if we could reduce vitriolic acid to earth and water, and make that acid by combining together these two principles, this theory would cease to be a system, and would become a demonstrated truth. But we must confess that this theory is less supported by experiment than by argument, from the many difficulties that are inevitable in such inquiries. For on one side, we know that the simpler bodies are, the more difficult is their decomposition; and on the other side, the stronger the aggregation is, the greater is the difficulty of making it enter into a new combination. Thus, as vitriolic acid is very simple, since it is a compound of the first order, it ought strongly to resist decomposition; and as the aggregation of pure earth is the firmest that we know, it cannot easily be made to enter as a principle into a new combination with water to form a saline matter. The following are the principal experiments which have been made relative to this subject.

First, we seem to be certain, from many proofs, that all saline substances, comprehending those that contain vitriolic acid, as vitriolated tartar, Glauber's salt, and other vitriolic salts which are sufficiently fixed to support a perfect drying, or rather calcination, being alternately dissolved, dried, and calcined a number of times, are more and more diminished in quantity, and that earth and water are separated from them each operation. But alkaline salts appear to be still more susceptible than any other saline matter of this kind of decomposition.

Secondly, when nitre is burnt in close vessels, so that we may retain not only all that remains fixed after this burning, but also what exhales in vapors, as in the experiment of the clyssus of nitre, we have a proof which seems decisive,

that

that the mineral acid of this falt, which is not very far from the fimplicity of vitriolic acid, is totally decompofed and reduced into earth and water. For if we examine the fixed refiduum in the retort, we find that it is only the alkali that was contained in the nitre, charged with a fuperabundant earth, which is feparable from it by folution and filtration. And if the liquor in the receiver, formed by the vapors condenfed there, be examined, which ought to be nitrous acid, if this acid had not been deftroyed, we find that, fo far from being acid, it is only pure water, fometimes even charged with a little fixed alkali, which had been raifed by the force of the detonation. Thus nitrous acid is made to difappear in this experiment, and in its place we find only earth and water. *See* Acid (Nitrous), Clyssus *of* Nitre, Detonation *of* Nitre, *and* Nitre.

Thirdly, the phenomena of limeftone, which by calcination and extinction in water acquires faline properties that it had not before, its attenuation by fire, and its combination with water; and alfo the experiment of Beccher, who afferts, that if a vitrifiable ftone be alternately made red-hot and extinguifhed in water a number of times, it may be fo attenuated, that it fhall be like a faline gelatinous matter; thefe, I fay, fhew that faline matters are actually formed by the intimate combination of the very attenuated parts of earth with thofe of water. We find in the writings of Beccher and Stahl, and particularly in the *Specimen Beccherianum* of the latter author, many other obfervations and experiments tending to prove the fame propofition; but we muft confefs that none of the experiments we have mentioned, excepting that of the decompofition of nitrous acid by burning, are abfolutely decifive, principally becaufe they have not been fufficiently repeated, or profecuted, nor carefully enough examined in all their circumftances.

Such is the actual ftate of the beft theory of faline fubftances hitherto given. However fine and probable it may feem, it requires to be further illuftrated, and better proved, efpecially by experiments. They who love inquiries into the fublimeft parts of chemiftry cannot engage in a more interefting fubject.

As fubftances effentially faline, and particularly thofe of their combinations which are called *falts*, are very numerous, we fhall here merely enumerate them, that we may have them at one view. For the details we refer to the particular article of each of thefe faline matters. We fhall fee by this kind of view, that although many combinations are known, many alfo are not known, becaufe they have never been made; and many others are known but imperfectly, becaufe they have not been fufficiently examined.

Subftances effentially faline are, acids, alkalis, and neutral falts with bafis of alkali.

The fimpleft and ftrongeft acids, called *mineral acids*, are, *vitriolic acid*, called alfo *univerfal acid*, or *faline principle*:

Nitrous acid, commonly called *fpirit of nitre* or *aqua fortis*:

Marine acid, called alfo *fpirit of falt*, and *acid of common falt*. See *all thefe articles*.

The acids lefs fimple and lefs ftrong than the mineral acids are thofe which have entered into the combinations of vegetables and animals, and which are united to a certain quantity of oil more or lefs attenuated. Thefe are cryftallized

effential acid falts, fuch as *tartar*, called *cream* or *cryftals of tartar*, when it is purified. *See* TARTAR.

The *acid of vinegar*, which proceeds from an acid fermentation, and is itfelf not only oily, but alfo fpiritous. *See* VINEGAR.

The *unfermented acids of fharp fruits and plants*, as the juice of *goofberries*, *citrons*, *forrel*, &c. Thefe acids have not been examined.

The acids and acid fpirit, obtained in the diftillation of vegetables, of their extracts, effential falts, oils, balfams, and refins. As all thefe acids are united to an empyreumatic oil, they may be called *empyreumatic acids*. They have not been examined.

The *acids obtained from animal fubftances* are;

The acid obtained in the diftillation of *ants*, *flies*, and other *infects*; and the acid obtained in the diftillation of *butter* or of *fat*. Thefe acids are empyreumatic; they are very volatile, pungent, and penetrating. They have not been examined. *See* BUTTER *and* FAT.

Phofphoric acid, the origin and nature of which are not fo well known that we can determine to what kingdom it belongs. *See* PHOSPHORUS *of* KUNCKEL, *and* SALT (FUSIBLE) *of* URINE.

Alkalis or *faline alkaline fubftances* are,

The fixed alkali of common falt, called alfo *mineral* or *foffil alkali*, *marine alkali*, *cryftals and falt of foda*, becaufe it is obtained by lixiviation and cryftallization, from the afhes called *foda*.

Vegetable, or *common fixed alkali*. It is often called falt of tartar, or alkali of tartar, in the works of chemifts, becaufe the afhes of tartar furnifh the largeft quantity of it. Both thefe fixed alkalis are called *cauftic fixed alkali*, when they have been altered by quicklime, or by metallic calxes. *See* ALKALI (FIXED).

Volatile alkali. That is called *fluor volatile alkali* which has been altered by quicklime, or by metallic calxes, fo that it afterwards cannot be obtained in a folid or concrete form. *See* ALKALI (VOLATILE).

NEUTRAL SALTS.

Formerly thofe only were called neutral falts which were compofed of acids and alkalis united together to the point of faturation, fo that they had no acid or alkaline property, and thence they were called neutral. But now this name is commonly extended to combinations of acids with all fubftances with which they can fo unite, that they lofe entirely, or moftly, their acid qualities. As, for inftance, when they are united with earthy or metallic fubftances. We fhall enumerate thefe neutral falts, obferving the order of the acids already enumerated.

VITRIOLIC SALTS.

Vitriolic acid, combined with marine alkali, forms a falt known by the name of *Glauber's falt*, or *fal mirabile*, [illegible]

With fixed vegetable alkali it forms a salt called *vitriolated tartar*, *sal de duobus*, and *arcanum duplicatum*. *See these names.*

With volatile alkali, it forms an ammoniacal salt, called *vitriolic ammoniacal salt*, and *secret sal ammoniac of Glauber*. *See* AMMONIAC (SALT).

With calcareous earths, it forms *vitriolic salts with basis of calcareous earth*, known by the general name of *selenites*. *See that word.*

With argillaceous earth, it forms a *vitriolic salt with basis of argillaceous earth*, called *alum*. *See* ALUM.

With metallic substances, it forms different *vitriolic salts with metallic bases*, to which we ought to give the general name of *vitriol*, together with the name of the particular metal subjoined. Thus;

With gold, a salt little or not known, which may be called *vitriol of gold*.

With silver, a salt but little known, *vitriol of silver*.

With copper, a salt known by the name of *vitriol of copper*, or *blue vitriol*.

Vitriols are in commerce more generally called *copperas*. Accordingly, this is called *blue copperas*. It is also sometimes named *cyprian vitriol*.

The same acid with iron forms *vitriol of iron*, called *green* or *martial vitriol*, or *green copperas*.

With tin, it forms a salt little known, a *vitriol of tin*.

With lead, a salt little known, a *vitriol of lead*.

With quicksilver or mercury, a salt not yet well known, a *vitriol of mercury*.

With regulus of antimony, a salt little known, a *vitriol of regulus of antimony*.

With bismuth, a salt little known, a *vitriol of bismuth*.

With zinc and calx or flowers of zinc, a *vitriol of zinc*, known by the name of *white vitriol*, *white copperas*, *vitriol of Goslar*.

With regulus of cobalt, a *vitriol of cobalt*, very little known. Mr. Beaumé has begun to examine it.

With regulus of arsenic and arsenic, a *vitriol of arsenic*, or *arsenical vitriol*, very little known. *See the articles* ACID (VITRIOLIC) *and* VITRIOL, *and those of the saline alkalis*, *earths*, *and metallic substances*.

NITROUS SALTS.

Nitrous acid, combined with all the substances of which we have just mentioned the combinations with vitriolic acid, forms salts to which we may give the general names of *nitre* or *nitrous salts*, specifying each salt by the name of the substance united with the acid.

Nitrous acid with fixed vegetable alkali forms *ordinary nitre*, or *saltpetre*.

With marine alkali it forms *cubic* or *quadrangular nitre*.

With volatile alkali, [illegible] *ammoniacal salt*, or *ammoniacal nitre*.

With calcareous [illegible] *with basis of calcareous earth*,

With argillaceous earth, *nitre with basis of argillaceous earth*, a kind of [illegible]

[illegible]

[illegible] unknown.

With [illegible] *lunar nitre*, *lunar crystals*, or *crystals of silver*.

With copper, *nitre of copper*, or *cupreous nitre.*
With iron, *nitre of iron*, or *martial nitre.*
With tin, *nitre of tin*, unknown.
With lead, *nitre of lead*, or *crystals of lead.*
With mercury, *nitre of mercury*, *mercurial nitre*, *crystals of mercury.*
With regulus of antimony, *nitre of antimony*, unknown.
With bismuth, *nitre of bismuth*, *crystals of bismuth.*
With zinc, its calx and flowers, *nitre of zinc*, unknown.
With regulus of cobalt, *nitre of cobalt*, not much known. Mr. Beaumé has begun to examine it.
With arsenic and its regulus, *nitre of arsenic*, or *arsenical nitre*, very little known. *See* NITRES (METALLIC), *or with* METALLIC BASES. *See also the articles* ACID (NITROUS), *the articles of all the substances we have mentioned, and those of the nitrous salts which have particular names.*

MARINE SALTS, *or simply*, SALTS.

Marine acid forms with all these substances salts which may be called by the general name of *marine salts*, or simply *salts*, and specified by the names of their particular bases. Thus,

With marine alkali, it forms *common salt*, *kitchen salt*, *sea-salt*, when extracted from the sea, and *sal gem* when dug from the earth.

With fixed vegetable alkali, *common salt with basis of vegetable alkali*, called *febrifugal salt of Sylvius* improperly, because it is no more febrifugal than any other; and still more improperly called *regenerated sea-salt*, because it differs essentially from sea-salt by the nature of its basis.

With volatile alkali, it forms *sal ammoniac*, formerly *armoniac*, and by some chemists called *salmiac.*

With calcareous earths, a *salt with basis of calcareous earth.* As this salt is obtained in the decomposition of sal ammoniac by means of quicklime, or other calcareous earths, chemists have improperly called the salt made in this manner *fixed ammoniac*, when it is dry; and *oil of lime*, when it is liquid.

With argillaceous earths, it forms a *salt with basis of argillaceous earth*, very little or not known.

With metallic substances, it forms *salts with metallic basis*, specified by the name of each base. Thus,

With gold, it forms a *salt of gold*, [illegible]
With silver, it forms a *salt of silver*, [illegible]
With copper, it forms a *salt of copper*, [illegible]
With iron, a *salt of iron*, [illegible]
With tin, a *salt of tin.* [illegible] acid with metallic matters, may be [illegible] metal in the acid: but it may be [illegible] by [illegible] assistance of heat, and by means of the metal intended to be [illegible] acid, a combination already made [illegible] ; which is always possible when the [illegible] than that of the metal already [illegible]

lizable salt of tin, by dissolving this metal directly in marine acid in the usual manner: this salt is but little known. The same combination is made by decomposing corrosive sublimate by means of tin, and by distillation. Thus we may obtain a combination of tin with marine acid, one part of which passes with excess of acid in form of a very smoking liquor, called *smoking spirit of Libavius*; and the other part which does not smoke, and which contains a larger proportion of tin, is sublimed in a solid state, and is called *butter of tin*.

With lead, *salt of lead*, known also by the name *plumbum corneum*.

With mercury, *salt of mercury*. It has different names according to the manner of making it, and according to the proportions of marine acid and mercury. It is called *white precipitate*, when it is separated from the nitrous acid by means of marine acid; *mercury corrosive sublimate*, or simply, *corrosive sublimate*, when it is actually sublimed, and with such proportions of mercury and acid, that a very corrosive salt results from them; *sweet mercury*, *sweet sublimate*, and *aquila alba*, when sublimed with an additional quantity of mercury by which its corrosive quality is blunted.

With regulus of antimony, it forms an *antimonial salt* by distillation. It is called *butter of antimony*.

With bismuth, it forms a *salt of bismuth*, not much examined.

With zinc, and its calx and flowers, a *salt of zinc*, little known.

With regulus of cobalt, a *salt of cobalt*, also little known.

With arsenic and its regulus, a *salt of arsenic*, or *butter of arsenic*, little known.

We may observe concerning all these combinations of marine acid with metallic matters, that, as this acid is very volatile, and as it is capable of adhering strongly with these substances, it does accordingly carry along with it more or less of them in sublimations and distillations; which is the reason that these salts are variable, as to the proportions of acid and metal which unite together, or which remain united, either directly by solution, or by distillation and sublimation; as we see from the phenomena exhibited by corneous metals, as tin and regulus of antimony. Although chemists, and still more, alchemists, have operated much on certain combinations of metallic substances with marine acid, much yet remains to be done to illustrate this subject.

We may here observe, that aqua regia, composed of nitrous and marine acids, which is in general a good solvent of metallic matters, must form with many of them mixed salts, some of which are perhaps of peculiar natures; but these combinations do not seem to have been examined hitherto as salts, no more than many others, as we may easily see from the present enumeration. *See the article* [illegible] *and of the several substances with which we have mentioned its combinations.*

TARTAREOUS SALTS.

We shall give that name to the combinations of the acid of tartar, or of [illegible] with the several substances [illegible] few of these salts are known, which are in general called *soluble tartars*, because they are all more soluble in water than the acid of tartar itself.

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The combination of cream of tartar with fixed vegetable alkali forms a neutral cryſtallizable ſalt, called *ſoluble tartar*, *tartariſed tartar*, and *vegetable ſalt*. *See this latter word.*

With marine alkali, it forms the ſalt known by the name of *ſalt of Seignette*, *ſal polychreſt*, *ſalt of Rochelle*.

With volatile alkali, a *ſoluble ammoniac tartar*, unknown.

With calcareous earths, *ſoluble tartars with baſis of calcareous earth*, very little known, but which appear ſimilar to the *ſoluble tartars with baſis of fixed alkali*.

With argillaceous earths, *ſoluble tartars with baſis of argillaceous earth*, unknown.

With metals, *ſoluble tartars with metallic baſes*, *ſoluble tartars of gold*, *of ſilver*, &c. which are all unknown, excepting the ſoluble tartars with baſis of *iron* and of *glaſs of antimony*. The former is deliqueſcent, and called, when liquid, *tartariſed tincture of iron*, or *of Mars*, and when evaporated, *martial extract*. It ought to be called *ſoluble martial tartar*. *See* TARTAR (SOLUBLE), and *the other names here mentioned.* The ſecond ſoluble tartar with metallic baſis is called *emetic* or *ſtibiated tartar*. *See* TARTAR (EMETIC).

ACETOUS SALTS.

We ſhall give this name to all ſalts containing the acid of vinegar.

With fixed vegetable alkali, it forms a *deliqueſcent ſalt*, called improperly *terra foliata tartari*, and *regenerated tartar*.

With marine alkali, it forms a cryſtallizable ſalt not much known, to which no name has been given. It may be called *acetous ſalt with baſis of marine alkali*.

With volatile alkali, an *acetous ammoniacal ſalt*, imperfectly known, and named *ſpirit of Mindererus*.

With calcareous earths, ſeveral *acetous ſalts with calcareous baſes*, very ſimilar one to another, and ſuſceptible of cryſtallizing, and forming beautiful *ſilky vegetations*, ſome of which are ſuperficially known, and named *ſalts of chalk*, *of crabs eyes*, *of coral*, &c.

With argillaceous earths, *an acetous argillaceous ſalt*, unknown.

With metallic ſubſtances, an *acetous ſalt with metallic baſis*, *of gold*, *ſilver*, &c. which are all unknown, excepting the three following:

With copper, an *acetous ſalt of copper*, known in chemiſtry by the names, *cryſtals of Venus*, or *of verdigriſe*, and in commerce and arts by the name *diſtilled*, or *cryſtallized verdigriſe*.

With lead, an *acetous ſalt of lead*, known by the name of *ſalt*, or *ſugar of lead*.

With mercury, an *acetous mercurial ſalt*, lately [illegible] known.

VEGETABLE SALTS.

This general name may be given to all [illegible] and *juices*, *concrete ſalts*, [illegible]

substances capable of uniting with these acids; but none of these salts are yet known.

VEGETABLE EMPYREUMATIC SALTS.

Neither do we know any thing of the salts which might be formed with the acids obtained by the distillation of vegetable matters, which furnish acid spirits or concrete acids, and which might be called *vegetable empyreumatic salts*.

ANIMAL EMPYREUMATIC SALTS.

By this name we may distinguish neutral salts composed with acids obtained from the distillation of animal matters, as the *acids of insects*, *of butter*, and *of fat*; but all these salts are perfectly unknown.

Although we have given the epithet *empyreumatic* to salts formed with vegetable and animal acids, obtained by distillation of these substances with a heat greater than that of boiling water, we do not mean to imply, that these salts, if they were well made and purified, would retain an empyreumatic character, or any part of the burnt oil which adheres to these acids after distillation. On the contrary, these acids may be deprived entirely or partly of this oil by passing into combinations of neutral salts, as happens to volatile alkalis when transformed into ammoniacal salts; but in this case we should be better able to examine the nature of these acids, and the epithet empyreumatic would only refer to the manner of obtaining them, and would serve to distinguish them from those vegetable or animal salts, the acids of which have been obtained without distillation in a naked fire.

PHOSPHORIC SALTS.

By this general name we mean all salts produced by combining the acid of *phosphorus of urine* with alkaline, earthy, and metallic substances, a small part of which salts is known even imperfectly.

With fixed vegetable alkali, this acid forms a *phosphoric salt*, a kind of *fusible salt of urine*.

With marine alkali, it forms another *phosphoric salt*, or *fusible salt of urine with basis of marine alkali*. It is [illegible].

With volatile alkali, a *phosphoric ammoniacal salt*, called also *fusible salt of urine*, [illegible] *salt*.

With calcareous and argillaceous earths, *phosphoric, calcareous, and argillaceous salts*, not known.

With metallic substances, *phosphoric metallic salts of gold, silver, copper*, &c. very little known. See the article PHOSPHORUS.

Besides the saline substances which have sensible acid properties, some substances, as [illegible] and arsenic, without having these properties, do nevertheless

[illegible]

nevertheless act as acids in their combinations with all substances capable of uniting with true acids, of forming with these substances kinds of neutral salts, and even of communicating, like the acids properly so called, saline properties to those substances which have them not. These combinations are by general consent classed amongst neutral salts.

BORAX, *or* SALTS *of* BORAX.

The sedative salt, combined with marine alkali, forms *ordinary borax*.

With fixed vegetable alkali, a kind of *borax*, not much known.

With volatile alkali, an *ammoniacal borax*, not much known.

With calcareous and argillaceous earths, *calcareous* and *argillaceous borax*, unknown.

With metals, *borax with metallic bases of gold, silver*, &c. unknown.

ARSENICAL SALTS.

Arsenic forms, with fixed vegetable alkali, a neutral salt perfectly soluble in water, and crystallizable, called by Mr. Macquer, who first observed it, *neutral arsenical salt*, or simply *arsenical salt*. *See* ARSENIC, *and* SALT (NEUTRAL ARSENICAL).

With marine alkali, another arsenical salt, very like the former, but not much examined.

With volatile alkali, an *arsenical ammoniacal salt*, unknown.

With calcareous and argillaceous earths, a *calcareous* or *argillaceous arsenical salt*, unknown.

With metallic substances, arsenic is perhaps capable of forming *arsenical salts with metallic bases*, or combinations in which saline properties would be perceptible, if these combinations were made by decomposing nitrous salts with metallic bases by means of arsenic, or by precipitating metals dissolved in acids by means of a solution of neutral arsenical salt in water; but perhaps from thence nothing would be produced but combinations similar to the arsenical minerals. We are quite ignorant upon this subject.

Saline alkaline substances, besides the salts which they can form with acids, can also act upon earths and metals, with which they form saline compounds, and from which, when separated, they appear as before. Accordingly, these compounds may for this reason be ranked amongst salts, and general and particular denominations may be assigned to them, according to the principles which compose them, as, for example, [illegible] *vitreous*, *metallic*, as of *gold*, *silver*, [illegible] sidered them in this view, and [illegible]

Lastly, acids, alkalis, and even [illegible] neutral salts may [illegible] oily substances, form compounds which may be considered as [illegible] name be given, as it ought to be, to every thing that is [illegible] water: but these compounds form in some measure a [illegible] distinguished by the name of *soaps*. See Soap.

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From this enumeration of saline compounds we may see how many of them are little known, or not even thought of. The numerous experiments yet to be made in this extensive part of chemistry are nevertheless very necessary, and are fundamental and elementary. To make them successfully, nothing is requisite but accuracy, patience, and knowledge of the first principles of chemistry. Every intelligent person is capable of making them. For this purpose the acids, alkalis, earths and metals employed must be very pure, the saline compounds resulting from their union must be examined; their taste, solubility in water, crystallization, deliquescence, and the methods of decomposing them must be observed. These considerations are certainly sufficient to excite the zeal of persons who would contribute to the progress of chemistry.

We now proceed to treat summarily of the principal salts known by the name of salts, in an alphabetical order.

ACID SALTS.

Some chemists, and particularly ancient chemists, have thus named the saline substances which we only call *acids*. *See* ACIDS. We may however continue this name, and apply it to some concrete saline substances, as *tartar*, salt of *sorrel*, &c. and to several other essential salts, which seem to be intermediate betwixt the state of pure acids and of neutral salts.

SALTS *with* BASES ALKALINE, EARTHY *and* METALLIC.

By these general denominations the several neutral salts are distinguished according to the nature of the basis, or substance with which the acid is combined. *See the above enumeration of salts. See also the article* NEUTRAL SALTS.

SALT ALEMBROTH.

This is a saline matter, composed of *corrosive sublimate* and of *sal ammoniac*, mixed in equal parts, or in other different proportions, which the ancient chemists, especially the alchemists, have much employed as a powerful solvent of metals, and even of gold. We are certain that corrosive sublimate and sal ammoniac act powerfully one upon another, and combine together without being decomposed, from which is formed a saline compound of a singular nature, capable of acting very effectually upon metallic substances. But the alchemists, who made so much use of this famous solvent, were far from understanding clearly the operations in which they employed it. As alchemists loved pompous names, they called this compound *salt of art*, *salt of wisdom*, *salt of science*.

ALKALINE SALTS.

This name is frequently given to saline alkaline substances, as *fixed alkalis*, *vegetable* and *mineral*, *volatile alkali*. *See these words.*

SALT *of* AMBER, *or* VOLATILE SALT *of* AMBER.

This is a saline, oily, concrete matter, obtained by sublimation, or even by crystallization, from amber. It is a kind of essential salt, which forms shining needle-like crystals, has the smell of rectified oil of amber, and is soluble in spirit of wine. It is used only medicinally, as an antispasmodic, with the same effect as the spirit and rectified oil of amber. *See* BITUMENS *and* SALTS (ESSENTIAL).

AMMONIACAL SALTS.

By this name are distinguished all neutral salts composed of any acid saturated with volatile alkali. *See* AMMONIACAL SALTS; *and* SALTS (NEUTRAL).

ARSENICAL SALTS.

See SALT (NEUTRAL ARSENICAL).

COMMON SALT.

Common salt is a neutral perfect salt, composed of a peculiar acid and a peculiar alkali, which are called *marine acid*, and *marine* or *mineral alkali*.

This salt, which is produced by nature, is more abundantly and universally diffused than any other. Immense mines or quarries of it are found within the earth, and it is then called *sal gem* or *fossile salt*. The waters of all the sea, and many subterranean and mineral waters, contain it. From every vegetable or animal chemists can extract it.

The taste of common salt is agreeable and moderately strong. It is crystallizable, and is one of those the figure of whose crystals is most regular, most determinate, and least variable. The crystals of this salt are perfect, or nearly perfect cubes; for the hollow pyramids obtained in certain evaporations of salt waters are nothing but a heap of cubical crystals, arranged in this manner near each other, by means of evaporation.

Common salt is moderately soluble in water. Four parts of water are required to dissolve one part of salt; and hot or boiling water dissolves no more of it than cold water. For which reason it is only obtainable from sea-water

water, and other waters impregnated with it, by a continued evaporation. See Crystallization.

Although common salt be very crystallizable, and exactly neutral, it very readily becomes moist when exposed to humid air. It must be preserved in very dry places.

This salt is susceptible of contracting a certain union with *common salt with calcareous basis*; for which reason all the salt obtained either from sea-water or salt fountains always contains a certain quantity of this salt with earthy basis. Thus, if any common salt be dissolved in very pure water, and fixed alkali be added to this solution, we soon see the white earth of the salt with earthy basis which is precipitated. As therefore crystallization seems insufficient for the purification of common salt from the salt with earthy basis, when we would obtain a very pure common salt, as is necessary for some delicate operations, we must dissolve it in water, filtrate it, and add to it a solution of crystals of soda, or marine alkali, till no more white cloud is formed by the addition; then filtrate again the liquor, and evaporate. By this method we shall obtain a common salt perfectly pure. (*q*)

Common salt exposed to the action of fire, crackles and decrepitates pretty strongly, when heated to a certain degree, especially if it be heated hastily. Its crystals burst into small pieces during this decrepitation. This effect is produced by the water of the crystallization of the salt, which being confined by the parts of the salt, and at the same time reduced into vapors by the action of fire, bursts the parts of the salt, and is dissipated. Many chemists consider this decrepitation of common salt as a property peculiar to it, and by which it may be known; but vitriolated tartar, nitre of lead, and probably many other salts, are susceptible of a similar decrepitation.

If salt be exposed to a red-heat after this decrepitation, it fuses; and when afterwards cooled, it fixes in form of a white and almost opake mass; but excepting that it has lost the water of its crystallization, it is the same as before this exposure to fire.

Several chemists, having observed that when common salt is heated in a retort, a little marine acid exhales from it while it contains any moisture, and that by adding more moisture, more acid may be thus obtained, have believed that, by means of water, all its acid may be expelled from it. But they have been deceived; for this small quantity of acid obtained by repeated humectations and distillations proceeded only from the common salt with earthy basis, which, we have observed, is always mixed with common salt. From this

(*q*) Sea-water contains dissolved in it not only sea-salt, or a combination of marine acid with mineral alkali, but also other salts, especially combinations of marine and vitriolic acids with the earth called magnesia, which is not calcareous. See MAGNESIA, *and the* [illegible]. Some of these salts, with basis of magnesia, are crystallized along with the sea-salt by the evaporation of the sea-water, and part of them remains in the residuous liquor called the mother-water. Some portion of true calcareous earth, dissolved by marine and vitriolic acids, is said also to be contained in sea-water; but the quantity of this is very small in comparison of the quantity of magnesia; to the precipitation of which, therefore, the cloud or turbid appearance given to sea-water or to a solution of common salt in water, is chiefly owing.

earthy ſalt a portion of acid may actually be obtained by this method: but Mr. Beaumé has found, that no acid can be thus expelled from common ſalt, perfectly purified in the above-mentioned manner.

This ſalt is abſolutely unalterable by fire, even when it has been heated ſtrongly, together with inflammable matters. The unalterable property of common ſalt by fire proceeds from the ſmall diſpoſition which its acid has to combine with phlogiſton. This truth has been demonſtrated by the experiments of Mr. Duhamel and of Mr. Margraaf.

Although this ſalt be fixed in the fire to a certain degree, yet when it is expoſed to a violent fire with free acceſs of air, it exhales in vapors, and attaches itſelf in white flowers to bodies which it finds leſs hot than itſelf. We have examples of this effect in certain fuſions of ores, where common ſalt is added; and in glaſs-houſe furnaces, where this ſalt, of which a certain quantity is contained in ſoda and potaſh, and which cannot enter into vitrification, attaches itſelf to the ſides of the openings or holes.

We know no other acid but vitriolic and nitrous acids, and ſedative ſalt, which can decompoſe common ſalt by diſengaging its acid: for arſenic, which ſo eaſily and effectually decompoſes nitre, cannot act upon this ſalt; a phenomenon, the cauſe of which deſerves to be examined, and which is certainly connected with an important theory.

Common ſalt is of all ſaline ſubſtances the moſt neceſſary, and extenſively uſeful. Beſides the particular uſes of its acid and alkali in many chemical operations and in arts; beſides its great utility in the fuſion of glaſs, which it whitens and purifies, although it does not enter, and perhaps becauſe it does not enter into their combination, as Mr. d'Antic has ſhewn; and from the property it has of facilitating the fuſion and precipitation of the metallic parts of minerals in eſſays, and of covering them perfectly; beſides theſe, I ſay, its great uſe in aliments, the taſte of which it improves by its agreeable piquancy, when mixed in proper quantity, is univerſally known. But this is not the only advantage; for it retards and prevents the putrefaction of almoſt all our aliments, without producing any ſuch change upon them, even when preſerved a long time by means of it, as to render them unfit for the purpoſe of nouriſhment. All other ſaline matters may indeed preſerve from putrefaction, as common ſalt does, and ſome of them even more effectually: but we do not know any other, the taſte of which renders it capable of being ſubſtituted to common ſalt for this purpoſe.

A very remarkable circumſtance in the antiſeptic property of common ſalt, and of ſome other ſalts, is, that this property varies ſurpriſingly according to the proportions in which the ſalt is employed; for this ſalt, mixed with animal matters in a large proportion, preſerves them from putrefaction, which it accelerates conſiderably when a ſmall quantity only of it is employed. This ſingular fact is proved by the experiments of Meſſrs. Pringle and Macbride, and particularly by thoſe of the accurate and intelligent author of an *Eſſay towards a Hiſtory of Putrefaction*, Mr. Gardane, Phyſician of the Faculty of Paris, who, having convinced himſelf of this fact by his own experiments, mentioned it in a very good theſis, and has drawn from it a concluſion which ſeems to me very juſt, namely, that ſmall quantities of common ſalt, ſuch as thoſe taken with aliments, facilitate digeſtion, which he conſiders as a beginning putrefaction.

putrefaction. If this opinion be as true as it is probable and confiftent with the principles of chemiftry, and of the animal economy, then common falt is not only agreeable and ufeful, but alfo falutary, at leaft to all conftitutions in which the digeftion is too remote from putrefaction, as in thofe which are properly called *crudities*: for we cannot but agree, that different temperaments differ much in this refpect. *See the articles* ACID (MARINE), ALKALI (MINERAL), CRYSTALLIZATION, WATER (SEA), WATER *of* SALT FOUNTAINS, SALTS, *and* SALTS (NEUTRAL).

CRYSTALLIZABLE SALTS.

By this name we diftinguifh all faline matters fufceptible of cryftallization. It is contrary to that of *fluor falts*, by which are diftinguifhed faline fubftances that cannot be obtained in a cryftallized concrete form, fuch as nitrous and marine acids, volatile alkali altered by quicklime, and fome others. We have neverthelefs reafon to believe, that, rigoroufly fpeaking, every faline fubftance is effentially fufceptible of cryftallization, and that in this refpect they only differ in the degree of facility with which they may be cryftallized; for we are certain that many very deliquefcent falts, the cryftallization of which has not, that I know of, been ever obferved, fuch as *common falt with calcareous bafis*, may neverthelefs affume folid regular forms by the cooling of their folutions when very much concentrated. Mr. Beaumé has obferved the cryftallization of this and feveral fimilar falts. *See* CRYSTALLISATION, DELIQUESCENCE, SALT, *and* SALTS (NEUTRAL).

SALTS *of* CENTAURY, *of* WORMWOOD, *of* SORREL, &c.

The name of *falt*, added to the proper name of fome fubftance, is applied to very different matters. It is given, for example, to all the fixed alkalis obtained from the afhes of vegetable matters. Salts of wormwood, centaury, &c. are faline matters obtained by lixiviating the afhes of thefe plants: but thefe names are improper in feveral refpects; for if we apply them to the fixed alkalis of plants, as they do not differ from each other, it is ufelefs to diftinguifh them by the name of the plant from which they are obtained; and even when they are prepared in Tachenius's method, although they differ a little, yet their character of fixed alkali is fo predominant, that no name ought to be given to them but what has a relation to that character. Accordingly, the names, *falt of tartar*, *falt of foda*, which are frequently given to the alkalis of thefe fubftances, are for the fame reafon very improper. They ought to be called *alkali of tartar* and *alkali of foda*.

Certain concrete acids, as the effential falt of forrel, tartar, &c. are alfo fimply called *falt of forrel*, &c. This is alfo faulty, becaufe thefe names do not denote the nature of the faline matters, and may be the occafion of confounding them with other falts of a very different nature. They ought to be named *effential falts*, or rather *concrete acids of forrel, of tartar*, &c.

The names *salts of coral, of pearls, of crabs eyes*, are not more accurate unless we add the epithet *acetous*, as *acetous salt of coral*, &c. for these substances may be combined, and may form salts with any other acid, as well as with vinegar.

Let us now judge if the names, *salt of quinquina, of sena, of onions*, &c. given to the dry extracts of these matters made in the manner of the Count de la Garaye, are not entirely improper. *See the preceding enumeration of salts.*

SALT *of* COLCOTHAR.

This is a white saline matter, obtained by lixiviating colcothar. This matter is not much used, and has not been much examined. It is probably some *selenitic* or *aluminous* substance, which is mixed with the vitriol, and which was contained in the pyrites from which the vitriol was extracted.

SAL DE DUOBUS.

It is a neutral salt, formed by saturating vitriolic acid with the alkali of nitre. *See* TARTAR (VITRIOLATED).

DELIQUESCENT SALTS.

Thus are named all saline matters which may be obtained by crystallization or drying in a concrete form, but which, when exposed to air, imbibe its moisture, and lose their concrete crystallized form, deliquiating into a liquor by means of this moisture. *See* DELIQUESCENCE.

SALTS *of* ENGLAND, *of* EPSOM, *of* SEDLITZ.

Some saline substances have been denominated from the countries where they have been first discovered. Thus a very rectified concrete volatile alkali, obtained from silk, is called *salt of England*; and even some druggists give this name to the concrete volatile alkali obtained from sal ammoniac.

In a similar manner, the name of Epsom salt is given to a badly crystallized, bitter Glauber's salt, which easily becomes moist, because it is mixed with common salt, and common salt with calcareous basis. It was first obtained from a salt well at Epsom near London. This name has been since given to a similar Glauber's salt obtained from salt-marshes in France, and also to a true and pure Glauber's salt obtained from the *schlot* of the salt-works of Lorraine and Franche-compté, the crystallization of which they disturb purposely to prevent it from resembling entirely the pure salt of Glauber.

Salt of Sedlitz is also a Glauber's salt under another name; and perhaps the same may be said of many other salts denominated from places.

ESSENTIAL SALTS.

This name is given to all concrete saline matters which preserve the smell, taste, and all other principal qualities of bodies from which they were obtained, which bodies are only vegetable and animal. The usual method of preparing them is by evaporating, to almost the consistence of a syrup, the liquors containing the essential salt, namely, the expressed and depurated juices and strong decoctions, and by keeping them in a cold place. From many of these liquors, saline matters or crystals are deposited upon the sides of the containing vessels after a considerable time, and after they have undergone a kind of fermentation. These crystals, which are always very red, may be purified by dissolving them in water, filtrating, evaporating, and crystallizing.

We may observe, that the salts thus obtained from animal and vegetable matters are sometimes nothing but vitriolated tartar, Glauber's salt, nitre, common salt, and other such neutral salts, which ought not to be considered as the essential salts of the substances from which they are extracted.

These mineral salts are extraneous to the vegetables and animals from which they are obtained. They are not parts of those substances, nor are combined with them; and when they are purified from the extractive matter with which they are at first only mixed and covered over, they have then nothing vegetable or animal. These salts are introduced into vegetables and animals along with aliments, are mixed in their liquors and circulate in their vessels, but receive no alteration, nor contract any true union with the proximate principles of animals and vegetables, because they are naturally incapable of such union.

The proof of this truth is, that they are always obtained from vegetables and animals in the same state in which they were introduced, and that their quantity in these substances is altogether unconstant and variable, without any real difference being produced in the vegetables or animals by this variation of the quantity of these salts. Certain plants, as the *parietaria*, but still more the *corona solis*, have the property of imbibing so much nitre, that, when they grow in nitrous soils, they are almost filled with this salt. I have seen the dried pith of corona solis so full of crystallized nitre, that when shook over a paper, a considerable quantity of good deflagrating nitre might be collected. But we know also that this plant, when cultivated in a less nitrous soil, does not contain nearly the same quantity of nitre, although it be otherwise in good condition. These mineral salts therefore must not be considered as the essential salts of plants or animals; and only those salts are to be considered as such, in the combination of which we find oily parts, which cannot be separated from them, unless the salt be decomposed.

In the second place we shall observe, concerning salts truly called essential, that but very few of them are yet known, and most of these but very imperfectly. Of all these essential salts the best known is tartar, the properties of which may be seen under the article TARTAR. The druggists have a very white concrete salt, well crystallized, and soluble in water, which they call *salt of sorrel*. We may indeed obtain from the juice of sorrel, by the above-mentioned process, an essential acid concrete salt, but much more earthy and less acid that

than the salt above-mentioned. Besides, Mr. Beaumé, who has made some inquiries into this matter, affirms, that a true salt of sorrel could not be procured at the price of the salt which is commonly sold under that name, the quantity of salt obtainable from sorrel being very small. The salt above-mentioned is brought from Germany, is much more acid and more soluble in water than cream of tartar; it acts upon all substances soluble by acids; but the neutral salts thence formed have not been examined.

Flowers of benjamin, *volatile salt of amber*, and other saline matters of the same kind, seem to belong to this class of essential salts; but they are little known. Essential salts may be considered as a new subject of inquiry.

FIXED SALTS.

Many chemists give this name to the salts obtained from the ashes of plants, which not having been dissipated by fire, ought to be considered as fixed, in comparison of the other saline matters of these plants, which evaporate during their deflagration.

As the saline substances remaining in the ashes of vegetables are entirely or chiefly alkaline, the name of *fixed salt* has become synonimous with that of *fixed alkali*. But other saline substances, as most neutral salts, which have not bases of volatile alkali, are nearly as fixed as fixed alkali.

The fixity of any saline matter is not perfect; since any of them by a long-continued violent fire may be altogether evaporated. A proof of this we find in glass-houses. A part of the fixed alkali, of the common salt, of Glauber's salt, of vitriolated tartar, and other equally fixed salts, contained in the ashes used in the composition of glass, are perpetually exhaling during the fusion of glass, in a vapor which may be seen above the pots; and this vapor forms saline incrustations round the openings and other least hot places of the furnace. Accordingly, the quantity of salt of glass which covers the surface of the melted glass is continually diminishing. I have had occasion to take from a vitrifying furnace, at different times, eighty crucibles, containing all the same composition for crystal-glass, of which soda and pot-ash made parts. The crucibles first taken out were covered with a crust of salt of glass more than two lines thick; those taken out 18 or 20 hours afterwards had only a very thin stratum of glass-gall; and, lastly, the crucibles which remained 72 hours in the fire, had no salt, or only a very small quantity, upon the middle of the surface of glass.

Hence we ought to conclude that the quality of fixity ascribed to some salts is only relative. We consider those as fixed, which sustain a red heat during several hours, without any sensible diminution. Salts which, by a moderate heat are reduced into vapors and sublimed, are called *semi-volatile*, as the ammoniacal salts, and corrosive sublimate; and lastly, salts which are evaporated without heat, or with very little heat, as the volatile acids and alkalis, are called *volatile salts*.

FLUOR SALTS.

This name is given to all ſaline ſubſtances which cannot by any method be rendered ſolid; ſuch are nitrous and marine acids, volatile alkali altered by quicklime, and ſome others. This quality depends on their volatility, and on the affinity which they have with water ſuperabundant to their ſaline eſſence. In this latter point they reſemble deliqueſcent ſalts, and they may even be conſidered as ſalts perpetually, and unſurmountably deliqueſcent. But they differ from ſalts that are only deliqueſcent, in this circumſtance, that theſe latter are much leſs volatile than the fluor ſalts, and can ſupport a heat ſufficient to deprive them of all their ſuperabundant water, and to reduce them to a concrete form. *See* DELIQUESCENCE *and* SALT.

FUSIBLE SALT *of* URINE.

This ſalt, called alſo *native* or *eſſential ſalt of urine*, *phoſphoric ſalt*, *microcoſmic ſalt*, is a neutral ſalt compoſed of an acid named *phoſphoric*, ſaturated with an alkali fixed or volatile; for both theſe kind of alkalis ſeem to be contained in urine.

To obtain this ſalt, urine freſh or putrid is to be evaporated to the conſiſtence of a ſyrup, ſlowly or quickly. This urine, which is then very red, or brown, is to be put in a cold place. The fuſible ſalt cryſtallizes on the ſides of the veſſel. When the ſalt ceaſes to form itſelf on the veſſel, the liquor is to be decanted, and again evaporated, that ſtill more cryſtals may be obtained by the ſame method. Theſe cryſtals are to be collected, which are very dirty and brown. They may be purified by diſſolving in pure water, filtrating, evaporating, and cryſtallizing, according to the general method. Theſe operations ought to be repeated when the ſalt is required to be very white and pure. Thus they are diſengaged not only from the extractive part of the urine which diſcolors them, but alſo from a portion of common ſalt which may be mixed with them, particularly when the urine has been much evaporated.

This ſalt is very ſuſceptible of cryſtallization, and is one of thoſe which are more apt to cryſtallize by cold, than by evaporation.

If this ſalt be expoſed to the action of fire in cloſe veſſels, a very pungent volatile alkali is expelled from it, which Mr. Schloſſer has obſerved to be always fluor, like that which has been altered by quicklime. This chemiſt affirms even that if concrete volatile alkali be combined with the fuſible ſalt of urine, and ſeparated from this ſalt by diſtillation, it will be in a fluor ſtate.

The acid of this ſalt is fixed, and remains at the bottom of the veſſels, melted to a viſcous matter, if the heat has been ſufficient for that purpoſe. This is the acid which produces the phoſphorus of Kunckel, by its combination with the inflammable principle, and which gives the characteriſtic properties to the fuſible ſalt of urine. *See the properties of this acid under the article* PHOSPHORUS *of* KUNCKEL.

If this fusible salt be mixed with the other fusible salt with basis of fixed alkali, as this latter salt cannot be decomposed merely by distillation, nor even by means of phlogiston, phosphorus is therefore chiefly produced from the former, or the ammoniacal fusible salt. *See* PHOSPHORUS *and* URINE.

FOSSIL SALTS.

Thus are called all the salts obtained ready formed within the earth; but more particularly common salt, which is coagulated in large masses within the earth, more frequently called *sal gem*.

SAL GEM.

Sal gem is fossil common salt, or which is found within the earth in large masses: It has some transparency, by which it resembles crystal a little; and hence it has been called sal gem. The most considerable mines of this salt are in Poland. Very curious and interesting particulars concerning these mines may be seen in a Memoir of Mr. Guettard, in the Memoirs of the Academy of Sciences.

SALT *of* GLASS.

This matter, called also *glass-gall*, is a kind of saline scum or mass, found in glass-house pots upon the surface of the melted glass. It consists of neutral salts, as common salt, vitriolated tartar, and others which are contained in the soda and potash employed in the composition of glass, and which not being themselves susceptible of vitrification, are separated from the glass during the fusion, and are collected together upon its surface, because they are specifically lighter. Hence we see, that as all the soda and potash employed for the composition of glass contain more or less of these extraneous neutral salts, the salt of glass must vary according to the saline substances employed. For the same reason no salt of glass is found where only pure and vitrifiable salts, as purified alkalis, nitre, borax, &c. are employed. *See* VITRIFICATION.

GLAUBER'S SALT.

The salt thus named, from the chemist who discovered it, is a neutral salt, composed of vitriolic acid saturated with marine alkali.

Glauber discovered this salt, while he was decomposing common salt by means of vitriolic acid, to obtain the smoking marine acid by distillation. The residuum of this distillation he found to be a saline mass, not crystallized, which he dissolved in water, and obtained, by evaporation and cold, transparent crystals. Glauber, surprised with the appearance and properties of these crystals, gave them

them the name of *sal mirabile*, by which they are still known, but more generally by that of *Glauber's* salt.

This salt, although composed of vitriolic acid and a fixed alkali, as vitriolated tartar is, yet it differs from this latter salt in many respects, which differences are to be attributed to the difference of the alkaline bases, one being the vegetable fixed alkali, and the other the marine fixed alkali. The taste of Glauber's salt is saltish but disagreable and bitter. It is one of the salts which form the finest crystals. When large quantities of this salt are crystallized, and with due attention, large, oblong, columnar crystals are formed, the surfaces of which are striated longitudinally, like those of nitre.

The crystals of this salt are as transparent as ice, but when exposed to a dry air they lose their transparency by the evaporation of the water of their crystallization. Their surface, and afterwards the whole of the saline mass, is reduced by the dissipation of this water to a white saline powder. This change also happens to the crystals of marine alkali, to which probably this property of Glauber's salt must be attributed.

The quantity of water which enters into the crystallization of Glauber's salt is very considerable, and amounts to nearly one half of its weight. To this large quantity of water is probably owing the size and transparency of the crystals: For it seems to be a general rule, that the more water is contained in any salt, the more large and transparent its crystals are. From this same abundance of water, Glauber's salt liquefies with a heat quickly applied, till all the water be evaporated; and then it becomes dry and solid, and requires greater degree of heat to fuse it.

This salt, although very soluble, even in cold water, is one of those which may be dissolved in a less quantity of boiling than of cold water. Hot water dissolves nearly an equal weight of it. From this property we may know, that the crystallization of Glauber's salt is best procured by the cooling of a sufficiently evaporated solution. Accordingly, a sure method of obtaining the finest crystals of salt of Glauber is, to evaporate the water, in which it is dissolved, till we find by taking out and trying a small quantity of the solution while evaporating, that crystals are pretty quickly formed by cooling. It is then to be poured into flat and shallow vessels, and cooled slowly. The larger the quantity of liquor is operated upon at a time, the larger will the crystals be; so that they may be obtained several feet long, and proportionably thick. These crystals are placed horizontally upon each other, and the crystallization ought therefore to be performed in wide vessels. *See* CRYSTALLIZATION.

Glauber's salt cannot be directly decomposed but by means of phlogiston only: For the decompositions made of it by metallic solutions are by means of a double affinity: and the decomposition which may be effected by the nitrous acid alone, upon Glauber's salt and vitriolated tartar, as Mr. Beaumé discovered, is also caused by phlogiston. (r)

(r) The singular decomposition of vitriolated tartar, and of Glauber's salt, by means of nitrous acid, as mentioned by Mr. Beaumé, does not seem to be caused by the phlogiston of the nitrous acid, as the author of the Dictionary believes; for Mr. Margraaf affirms, that these neutral salts, and also that nitre, may be decomposed in a similar manner by marine acid.

Glauber's salt is used only in Medicine. In small doses, as from one to two gros, it is resolvent and aperitive, and as such is added to ptisans and apozems. It is also employed as an attenuant and corrective in the same dose in purgative potions; and it is itself a good and mild purgative, as all the neutral salts are, the basis of which are fixed alkali. The dose of this salt as a purgative is from an ounce to an ounce and a half.

To prepare Glauber's salt, we need not combine the pure disengaged vitriolic acid with the alkali of soda, nor decompose common salt by vitriolic acid, as Glauber did, unless we desire to obtain at the same time the marine acid. Nature furnishes a large quantity of this salt ready formed. A considerable quantity of it is contained in mineral waters, and perhaps all waters which contain common salt contain also some Glauber's salt. (s) The salt wells of Lorraine, of Franche-compté, of Epsom, contain much of it, and from these it may be easily obtained by crystallization. Further, from all vitriolic salts with earthy or metallic bases, as selenites, alums, vitriols, Glauber's salt may be obtained by decomposing them with soda. Lastly, by burning sulphur with common salt or soda, this salt may be formed. If it were much wanted, it might be easily and cheaply made by these processes. *See the articles* Acid (Vitriolic), Alkali (Marine), Crystallization, Water *of the* Sea, *and of* Salt Fountains, Salt, *and* Neutral Salts.

SALT *of* LEAD.

Thus is commonly called the neutral salt composed of the acid of vinegar saturated with lead. As this salt has a sweet and saccharine taste, it is called *sugar of lead*.

To make this acetous salt, ceruss, which is lead half dissolved, and corroded by vinegar, is to be entirely dissolved in distilled vinegar by means of heat in a sand-bath; the liquor, when perfectly saturated, is to be evaporated, and crystallized by cooling, and many small needle-like crystals will be formed in it, which are to be well drained.

This salt is not much used in medicine. It is used only externally, because the lead is pernicious. It is employed in some arts, and especially in dyeing, to heighten the red color of madder. *See* Ceruss, Lead, *and* Vinegar.

(s) Glauber's salt, that is, a salt formed by vitriolic acid combined with mineral alkali, is contained in sea-water and in many mineral waters. But the *sal catharticus amarus* of the London Dispensatory, extracted from the bitter liquor remaining after crystallization of sea-salt in sea-water, and the *salt of Epsom*, and of most purging waters, tho' very similar in appearance to this [illegible] Glauber's salt, with which it is frequently confounded, is found to be composed of vitriolic acid united with the earth called magnesia. See *magnesia*. This [illegible] sists of prismatic crystals like those of [Glau]ber's salt, has a bitter taste, is so[luble in] less than an equal weight of wa[ter] [illegible] exposed to a moderate heat, it [illegible] quefies, and loses the water of its [crystal]lization, which [illegible] its weight; and is changed by this [illegible] [illegible] together with evaporation, it [illegible] to its former crystallized state.

LIXIVIAL SALTS.

This is a general name given to all saline substances obtained by lixiviation of ashes, but is particularly applied to fixed alkalis, because the salts thus obtained from ashes are altogether or mostly alkaline. *See* ALKALI (FIXED).

NEUTRAL SALTS.

If this name be taken in its most extensive sense, it ought to be given to all the combinations of any acids with any alkaline, earthy, or metallic substances. These are salts formed with basis of fixed alkali, vegetable or marine; with basis of volatile alkali, called ammoniacal salts; or with bases of calcareous and argillaceous earths; and, lastly, those with bases of metallic substances. *See the above enumeration of salts.*

The name *neutral*, given to these salts, relates to the reciprocal saturation of their acids and their bases. This saturation ought to be such, that the properties of the two principles of the neutral salt should be neither those of a pure acid, nor of its pure basis, but mixed or intermediate; and from hence these salts have also been called *intermediate salts*, or *sales medii*.

The most important consideration concerning these salts, is the just saturation of their two component principles. A neutral salt ought to be considered as perfect in its kind, when its acid and basis are each of them in the most perfect relative saturation; that is, when the acid and the basis are united together in as large quantity and as intimately as they can be, each according to its nature. But we must remark upon this subject, that a neutral salt may be perfect in its kind, and exactly saturated in the sense we have mentioned, altho' its principles be very far from being completely or absolutely saturated; that is, altho' they have not exhausted upon each other all their tendency to combine. In this respect the neutral salts differ much; and on this chiefly depend the essential differences evidently observable in the taste, solubility, crystallization, deliquescence, facility of decomposition, and action upon other substances, of these neutral salts.

* From a circumstantial examination only of the properties of neutral salts, we can acquire any knowledge concerning them; but we are far from having sufficiently examined them: for besides that many saline combinations are quite unknown, and have never been made, many things are yet undetermined even concerning those salts which are best known. We need not therefore be surprized that we cannot yet establish a good general theory concerning neutral salts. We shall here only mention some general principles which seem to result from what is already known, and which seem capable of leading us to further researches.

First, the neutral salts resulting from the union of acids in general with fixed alkalis, are more absolutely saturated than those with basis of volatile alkali, and these more than salts with basis of earth, excepting selenites; and, lastly, the salts with basis of earth are more absolutely saturated than salts with metallic bases. In the first class of these salts, namely, those with basis of

fixed

fixed alkali, we find most of the salts which have the least taste, solubility, deliquescence, action upon other bodies, or facility of decomposition, and the greatest tendency to crystallization. On the contrary, in the last class, namely, the salts with metallic bases, we find most of those that are corrosive, most soluble, deliquescent, least crystallizable, most active upon other substances, and most easily to be decomposed. The two intermediate classes with bases of volatile alkali, and of earth, are also intermediate with regard to these properties.

Secondly, as the several acids are more or less simple and powerful, they form with the substances to which they are capable of uniting, neutral salts, the absolute saturation of which is more or less perfect, according to the nature of the acid. Neutral vitriolic salts are the first in this respect, then nitrous and marine salts, or marine and nitrous salts; for these acids do not differ much; and, lastly acetous and tartareous salts.

We ought to observe upon this subject of general considerations upon neutral salts, that we must not judge, from one or a few of their properties, concerning the degree of cohesion and of absolute saturation of their principles, but from all their properties taken and compared together; because possibly one of the principles of a salt may be absolutely, or almost absolutely, saturated, while the other principle may be far from this degree of saturation; and according as the acid or the base is most saturated, the properties of the neutral salt must vary considerably. For example; we should be much mistaken, if, upon considering that corrosive sublimate is less soluble in water than common salt, and not at all deliquescent, as the latter salt is a little, we should conclude, that the cohesion of the principles of corrosive sublimate and their absolute saturation are much stronger than in common salt. The corrosive quality of this salt, and its powerful action upon many bodies, which properties do not, or scarcely, exist in common salt, evidently prove the contrary. See SUBLIMATE (CORROSIVE).

We must also observe, that in many combinations of neutral salts, and particularly of those with metallic bases, some metals and the acids themselves suffer, by the very act of combination, certain alterations which have great influence on the nature of the neutral metallic salt resulting from their union: for instance; although lunar and mercurial nitre be crystallizable, and little, if at all, deliquescent, while the nitres with bases of copper and of iron are very much so, we must not thence conclude, that iron and copper saturate the nitrous acid less than silver and mercury do; because we are certain that this difference does only proceed from this circumstance, that while the nitrous acid dissolves copper and iron, it decomposes them, and deprives them of much of their inflammable principle which is necessary to the connexion of metals with acids, while it does not produce the same effect so evidently upon silver and mercury. Accordingly, the salts, which result from the solution of copper and of iron by nitrous acid, ought not to be rigorously considered as combinations of these metals, but rather as combinations of their earth with this acid; for as nitrous acid quits silver and mercury to dissolve copper and iron, probably if this solution could be made without loss of the phlogiston of these latter metals, they would more compleatly saturate this acid, and more firmly adhere to it, than the former metals.

Many

Many other considerations of this kind may be made concerning the different kinds of neutral salts; but the detail of them would engage us too long, besides that they will easily occur to those who would attentively reflect on this subject. We will however mention something concerning a discussion that has arisen lately betwixt some chemists relative to neutral salts.

Mr. Rouelle had advanced, in a Memoir of the Academy in 1754, that several of these salts may be in two different states; that is, they may be in a state of a perfect saturation; or, they may have an excess of acid. He cites for examples several combinations of metallic matters with acids, such as those of mercury with marine acid and with vitriolic acid, and that of bismuth with nitrous acid. Each of these metals may, according to him, form with the same acid two very different neutral salts; one of which has an excess of acid, and contains the largest possible quantity of acid; and the other is precisely saturated, and contains the smallest quantity possible of acid. This chemist cites also, as another instance of the same doctrine, the combination of a fixed alkali with an acid. It is that of the vegetable fixed alkali with vitriolic acid, forming consequently the neutral salt called *vitriolated tartar*. Mr. Beaumé has opposed this opinion in many Memoirs read at the Academy, and also in the Journal and Gazette of Medicine. He disputes the facts upon which Mr. Roulle establishes his theory. He maintains, that many of the saline metallic combinations cited by Mr. Rouelle as examples, and considered by him as neutral salts containing the least possible quantity of acid, are nothing less than salts; but metals, deprived of all acid, when the acid which adheres superficially to the precipitated metal is sufficiently washed from it; and he thinks that Mr. Rouelle has been mistaken, from not having sufficiently washed these metallic precipitates, which he considered as salts. Mr. Beaumé proves his opinion, by washing with a very large quantity of distilled and boiling water turbith mineral and mercurius vitæ; which precipitates he, by this method, deprived of every particle of acid.

With respect to the vitriolated tartar, the process by which Mr. Rouelle gives it an excess of acid is, by distilling in a retort two ounces of pure vitriolic acid upon this salt, till the salt is dry, and even till the retort has been kept red-hot during an hour. Mr. Rouelle observes, that when vitriolic acid is poured upon this salt, a considerable heat is excited, even when the salt has been deprived of the water of its crystallization by drying; and thence concludes, that the acid acts upon and combines with the salt. The saline mass remaining after the distillation melts, and weighs, as Mr. Rouelle has observed, five ounces and one gros. This, according to him, is vitriolated tartar with excess of acid. He affirms also, that in this salt, as in all those which are susceptible of receiving excess of acid, there is a point of saturation of this excess of acid, and this point is marked in the present operation by the ceasing of white vapors which rise during the distillation. This vitriolated tartar with excess of acid has really an acid taste, it attracts the moisture of the air, resolves in a liquor, like the deliquescent salts, reddens the tinctures of violets and of turnsol, effervesces with fixed and volatile alkalis; and, lastly, in crystallizing, remains acid.

Mr. Beaumé acknowledges almost all these facts; but he denies that we ought thence to conclude, that vitriolated tartar really contains an excess of combined acid. He supports his opinion upon the following facts and reasons:

Vitriolic

Vitriolic acid diftilled from pure fand, in the fame manner as Mr. Rouelle diftilled that acid from vitriolated tartar, adheres to it in the fame manner, although we are certain that it does not act upon fand. In this therefore, and in many cafes, it is only an adhefion of juxta-pofition, which vitriolic acid is capable of contracting with any body from the degree of fixity which it has, efpecially when perfectly concentrated.

In the fecond place, the vitriolic acid, with which Mr. Beaumé affirms the vitriolated tartar is only fuperficially covered, by Mr. Rouelle's procefs, is fo far from being truly combined, that it may be entirely feparated without fire, or any intermediate fubftances, by means purely mechanical: for by draining this falt very carefully upon brown paper, or even upon clean fand, a vitriolated tartar perfectly neutral may be obtained, which preferves the water of its cryftallization, and confequently the form and folidity of its cryftals, and which no longer contains any veftige of an acid. From thefe experiments Mr. Beaumé concludes, that this excefs of acid in vitriolated tartar is not real, and is, like the unwafhed metallic precipitates, miftaken for falts with the leaft poffible quantity of acid, one of thofe deceitful appearances againft which we cannot too much guard. Mr. Beaumé generalifes his propofition concerning the excefs of acid of vitriolated tartar, and affirms, that no neutral falt with bafis of fixed alkali either has an excefs of combined acid, or of combined alkali, although it be cryftallized in an acid or an alkaline liquor; and that the acid or alkali, with which thefe falts are mixed, when cryftallized in fuch liquors, is only interpofed betwixt their parts, and may always be carefully feparated from them folely by the mechanical method of imbibition.

We fhall not enter more particularly into thefe fubjects, which perhaps will hereafter be further illuftrated. We fhall only obferve, that if we were to examine thefe matters as well as they deferve, it feems effential to diftinguifh firft metallic falts from all others; for the greater or lefs degree of concentration of acids feems indifferent, with regard to the faline combinations which refult from the union of thefe acids with earths and alkalis both fixed and volatile; that is to fay, the fame quantity of acid remains united with the earths or alkalis, whether the acid employed be concentrated or diluted with water; but metals, efpecially fome certain metals, cannot be combined, or remain combined with acids, in the greateft poffible quantity, unlefs the acid employed be in a proper degree of concentration; fo that the fame quantity of the fame acid, which, when fufficiently concentrated, is capable of remaining united with a certain quantity of metal, can diffolve only a much lefs quantity of the fame metal, if this quantity of acid be diluted with a larger quantity of water.

This fingular phenomenon of metals relative to acids can be only attributed to the inflammable principle which enters into their compofition. Metals in general adhere only to acids by this principle, and not by their earthy principle, or at leaft much more by the former than by the latter: but on the other fide, the union of water with any body is an obftacle to the combination of that body with the inflammable principle. A quantity of acid therefore, diluted with water, cannot be united but with a lefs quantity of metal than the fame quantity of acid when concentrated. This feems to be naturally deduced from the fundamental principles of chemiftry.

In

In the second place, we may remark, that after having distinguished metallic salts from all others, we ought also to distinguish the combinations of mercury and marine acid, and even the corneous metals, from all other metallic salts. These salts make a distinct class, and have a peculiar character. *See upon this subject the article* SUBLIMATE (CORROSIVE).

Notwithstanding the distinctions we have shewn between the different kinds of neutral salts, we are far from believing that they can be methodically distributed, from considering any of their common properties, or classed, as plants have been by botanists; because each of them has so many peculiar, and, at the same time, very essential, properties, that the salts in the same class would often differ more from each other in their peculiar properties than they would be similar in their common property by which the class is characterised. A proof of this truth may be seen in a Memoir inserted in the Collection of the Academy for the year 1744, in which Mr. Rouelle has undertaken to class neutral salts according to their crystallization: for we find very different salts ranged not only in the same section, but also under the same genus, as, for instance, *sal ammoniac*, and the *combination of lead with marine acid*. We do not mean to depreciate Mr. Rouelle's attempt upon this subject, or those of others in the same way, as we are convinced, that however unsuccessful these may be in their particular object, they must encrease our knowledge by the many experiments and observations which they require, and by the comparisons and new views they occasion. We need only to read the above Memoir of Mr. Rouelle to be convinced of this.

Neutral salts have many uses in chemistry, arts, and medicine; but as these uses depend upon the peculiar nature of each of them, we refer to the particular articles; and here we shall only say a little concerning their medicinal virtues.

We may observe, that these salts are antiseptic when mixed in a proper dose, that is, in a large dose, with substances capable of putrefaction. Each of them resists all kinds of fermentation more or less effectually: but the most exact experiments that have been made on this subject by Sir John Pringle, by the author of the Essay on Putrefaction, and by Mr. Gardane, physician at Paris, prove that these neutral salts, the principles of which are firmly connected, as all those with basis of fixed alkali, particularly common salt, rather accelerate than retard putrefaction. We find, from the experiments of the author of the Essay on Putrefaction, that the most powerful antiseptics among the neutral salts are those which are most astringent, as the neutral salts with metallic bases.

All neutral salts with basis of fixed alkali taken internally in the dose of an ounce or more, produce in general a very mild purgative effect; and in small doses, as of one or two gros, they are only aperitive.

Ammoniacal salts are given in small doses only. They are exciting, dividing, and [illegible]. The common sal ammoniac is the only ammoniacal salt used.

Neutral salts with basis of calcareous earth are also considered as aperients and diuretics, but [illegible] much according to the nature of their acids. [illegible] differ in their effects from nitrous and marine salts with calcareous basis. Of these salts, only the acetous, such as the salts of coral, pearls, &c. are employed, and these but very little in France.

All

All the salts with metallic bases are corrosive, especially those containing mineral acids. Accordingly, they are not internally employed in medicine, excepting some of those with bases of mercury, iron, regulus of antimony. *See the articles* IRON, MERCURY, REGULUS *of* ANTIMONY, *and* TARTAR (EMETIC).

NEUTRAL ARSENICAL SALT.

This salt is a combination of arsenic with fixed alkali to the point of saturation. Mr. Macquer first discovered this combination, and began an account of its properties in the Memoirs of the Academy for the years 1746 and 1748. His method of making this salt is, by mixing together equal parts of very white crystalline arsenic and purified nitre, and by distilling this mixture in a retort with a graduated heat in the usual manner, till the retort is red-hot, and no more vapors of nitrous acid arise. In the retort a saline mass remains, white, compact, and fixed; from which, after solution in hot water, filtration, evaporation, and crystallization, may be obtained beautiful, quadrangular, prismatic crystals, terminated at each end by a quadrangular pyramid, the sides of which correspond with those of the prism.

Arsenic is known to have the property of decomposing nitre, and of very easily disengaging its acid; but, at the same time, it combines with the alkali of the salt, and saturates it precisely as an acid would do; so that the new salt which results from this operation when well made, is exactly neutral, and gives no marks of an alkaline quality. It is infinitely more soluble in water than pure arsenic, and dissolves in a less quantity of hot than of cold water.

This salt is easily fusible by fire, and remains fused and transparent like glass, without being alkalised, if it has not touched any inflammable matter: for it may be easily decomposed by phlogiston which unites with the arsenic, separates it from the alkali, and is sublimed. No pure mineral acid can decompose this salt, because arsenic seems to have a greater affinity with fixed alkali than acids have: but when these acids are united with metallic matters, they then easily decompose the neutral arsenical salt, even by the humid way; so that a solution of this salt added to a solution of metals occasions a precipitate composed of the arsenic and metal, while the acid of the metallic solution combines with the fixed alkali of the neutral arsenical salt, and forms another neutral salt. Thus two decompositions are made, and two new combinations are formed.

The uses of the neutral arsenical salt are not yet well determined; yet as the arsenic seems, from the properties mentioned, to be strictly united with the fixed alkali, this salt may probably be usefully employed, 1. for the preparation of the regulus of arsenic; 2. to combine arsenic conveniently with metallic matters; 3. in the composition of [illegible] glasses; 4. as the corrosive mineral acids form very mild salts when [illegible] with alkalis, we may be induced to believe that arsenic [illegible] a very mild salt [illegible] neutral arsenical salt [illegible] medicine; but the name of arsenic is [illegible] tried:

tried: but if it should, very numerous and long trials ought to be previously made on animals.

This salt might probably be useful in arts; for Mr. Beaumé prepares large quantities of it for different manufactures; but the uses to which it is applied are kept secret. *See* ARSENIC.

SALT *of* MILK.

Salt of milk is a neutral salt of a singular nature, and very little known. It is obtained from whey by evaporation and crystallization. As the evaporated whey from which it is obtained has a red color and a saccharine taste, that part of the salt of milk, which crystallizes first, has the same color and t ste; and hence it has been called *sugar of milk*. If it be required more white and pure, it must be again dissolved in pure water, and crystallized once or twice; and then it becomes very white, and has a farinaceous appearance even internally, although it is compact and hard. When thus purified, it is less saccharine, and has in general less taste; because it is disengaged from the saccharine part of the milk, and even from a little common salt, which may afterwards be separated from the whey.

Crystals of this salt seem to contain very little water: they have little taste, are not deliquescent, nor very soluble, and seem to be difficultly decomposed. They deserve a farther examination.

Some persons have imagined, that a liquor like whey might be made by dissolving salt of milk in pure water; but this salt is only one of the constituent parts of whey; and consequently the purer it is, the less can its solution imitate that liquor. *See* MILK.

SAL POLYCHREST.

The word polychrest is applicable to things which have many uses: accordingly chemists say, that a furnace is polychrest when it is so constructed that different operations may be made with it.

For the same reason, the inventors of some salts have given them this epithet to denote their various powers in medicine. Hence we have the *sal polychrest of Glaser*, which is a vitriolated tartar, made by the detonation of nitre with sulphur; the *sal polychrest of Rochelle or of Saignette*, which is a tartareous salt, or a soluble tartar with basis of marine alkali. *See* SALT *of* SAIGNETTE, *and* TARTAR (VITRIOLATED).

POTASH.

Potash is a impure, fixed, vegetable alkali, obtained from the ashes of wood. *See* ALKALI (FIXED VEGETABLE).

SALT *of* SAIGNETTE *or of* ROCHELLE.

This salt is a soluble tartar with basis of marine alkali, or a neutral salt formed by saturating the acid of tartar with marine alkali.

This salt was first composed for medicinal purposes, in imitation of ordinary soluble tartar or vegetable salt, by Mr. Saignette, apothecary at Rochelle, who brought it into vogue, and kept it secret as long as he could. Mess. Boulduc and Geoffroy afterwards discovered, and published its composition.

To prepare this salt, crystals of marine alkali are to be dissolved in hot water, and into this liquor powdered cream of tartar is to be thrown: when the effervescence ceases, more cream of tartar is to be added, till the liquor is saturated: it is then to be filtered and evaporated; and very fine and large crystals may be obtained by cold, each of which is the half of a polygonous prism cut in the direction of its axis. This section, which forms a face much larger than the rest, is, like them, a regular rectangle, distinguishable however from the others, not only by its breadth, but also by two distinct diagonal lines which intersect each other in the middle.

Mr. Beaumé has observed, that the crystallization of this salt, and also of the vegetable salt, is much more easy and beautiful when the liquor in which it is made contains an excess of alkali, which does not prevent the salt from being exactly neutral, after it has been well drained.

Salt of Saignette has a saline taste, moderately strong, and disagreeable. It retains much water in its crystallization, is soluble in a less quantity of hot water than of cold water, and consequently crystallizes well by cold. It becomes farinaceous in a dry air, both from the quantity of water of its crystallization, and from the marine alkali which enters its composition. In other respects, it has all the general properties of *neutral tartareous salts*, or *soluble tartars*.

Salt of Saignette is used only in medicine. It is a good purgative, taken from an ounce to an ounce and a half. It is much used as such, and is, for that purpose, dissolved in pure water, or in ptisans and mineral waters, to render them purgative. It is also given in small doses of one or two gros, as an alterative, aperitive, and corrector of other purgative substances. Altho' this salt really possesses these good qualities, it does not seem to differ much from ordinary soluble tartar, to which it is generally preferred. *See* TARTAR, ALKALI (MINERAL), *and* TARTAR (SOLUBLE).

SALES SALSI.

This is one of the names given to neutral salts, particularly to those which have a taste something resembling that of common salt. *See* SALTS (NEUTRAL).

SEDATIVE SALT.

This salt is a saline, concrete, and cryſtallized ſubſtance, obtained from borax by means of acids. This matter, although it acts as an acid in borax, and perfectly ſaturates its alkali, has not an acid taſte, nor the property of reddening the tinctures of violets and turnſol, as the acids properly ſo called do. Sedative ſalt has little taſte and ſolubility in water. It is a kind of neutral ſalt, which has only ſome properties common to it with acids, as we ſhall afterwards ſee.

Sedative ſalt may be obtained from borax by ſublimation, or by cryſtallization. The moſt common proceſs for obtaining this ſalt by ſublimation is that of Homberg, the diſcoverer of ſedative ſalt. This proceſs conſiſts in mixing martial vitriol with borax, in diſſolving them in water, in filtrating and evaporating the liquor till a pellicle appears: the liquor is then to be put in a ſmall glaſs alembic, and the ſublimation is to be promoted till only a dry matter remains in the cucurbit.

During this operation, the liquor paſſes into the receiver; but the internal ſurface of the capital is covered with a ſaline matter forming very ſmall, thin, laminated cryſtals, very ſhining and very light. This is the ſedative ſalt. The capital is then to be unluted, and the adhering ſalt ſwept off with a feather: the part of the liquor which paſſed laſt into the receiver is to be poured on the dry reſiduum of the cucurbit, and a new ſublimation is to be promoted as before, by diſtilling till the matter in the cucurbit be dry: theſe operations are to be frequently repeated in the ſame manner, till no more ſedative ſalt can be ſublimed.

Sedative ſalt may be obtained by cryſtallization. For this purpoſe, let borax be diſſolved in hot water; and to this ſolution, when filtrated, add any one of the three mineral acids, a little at a time, till the liquor be ſaturated, and even have an exceſs of acid, according to Mr. Beaumé's proceſs: the liquor is then to be left in a cold place, and a great number of ſmall, ſhining, laminated cryſtals will be formed: Theſe muſt be waſhed with a little very cold water, and drained upon brown paper. This is the ſedative ſalt obtained by cryſtallization. It is very beautiful and ſhining, but is ſomewhat denſer than the ſalt obtained by ſublimation. This latter is ſo light, that one gros is ſufficient to fill a large phial.

The acids, either of the martial vitriol, or the diſengaged acids in the latter proceſs, do only diſengage this ſalt from the marine alkali with which it formed borax, as Mr. Baron has diſcovered. Accordingly, this ſalt, when well prepared, does not partake in any manner of the nature of the acid by means of which it has been diſengaged. Sedative ſalt obtained by cryſtallization does not differ eſſentially from that which is ſublimed, only that the cryſtals or laminæ of the latter are more ſeparated and detached than thoſe of the former.

Sedative ſalt, although it be thus ſublimed, is not however volatile; for, as Mr. Rouelle obſerves, it only riſes by means of the water of its cryſtallization. We know that, when once it has loſt its water by drying, it cannot be raiſed

into

into vapors by the most violent fire, in which it remains fixed, and melts into a vitreous matter, as borax does.

This vitrified ſedative ſalt preſerves its ſaline character; and, although it has a beautiful cryſtalline appearance, it is only ſedative ſalt deprived of all moiſture and melted. It is entirely ſoluble in water, and may then be cryſtallized or ſublimed, as at firſt, into its proper form.

A great quantity of water is required to diſſolve ſedative ſalt, and much more of cold than of boiling water. It may therefore be cryſtallized by cold, and is alſo cryſtallizable by evaporation alone.

Mr. Beaumé has made an intereſting obſervation upon this method of diſengaging and cryſtallizing ſedative ſalt, which is, that we muſt add a little more acid to the ſolution than is ſufficient for the ſaturation. He remarks, that when only the preciſe quantity of acid is added to decompoſe all the borax, the ſedative ſalt remains confounded with the other ſaline matters contained in the liquor and the cryſtallization is conſequently diſturbed. This inconvenience is avoided by the addition of a little more acid than is ſufficient for the ſaturation of the alkaline baſis of the borax. The ſedative ſalt, although formed in a liquor thus acidulated, may be entirely deprived of any exceſs of acid, which is not combined with it, by means of draining upon paper, according to the principles of Mr. Beaumé.

The acid that is mixed in the hot ſolution of borax decompoſes this ſalt, becomes ſaturated with its alkaline baſis, and inſtantly diſengages the ſedative ſalt; all which is effected without any effervеſcence. The ſedative ſalt does not cryſtallize as ſoon as it is diſengaged, although the liquor be at the point of cryſtallization, when only the preciſe quantity of water is added which is neceſſary for the ſolution of the borax. The heat is the cauſe of this; for as ſoon as the liquor cools, a conſiderable quantity of cryſtals is perceived.

From the above-mentioned properties of the ſedative ſalt, by which it reſiſts fire, ſo as to be capable of vitrification, without being otherwiſe altered, we may perceive that it is a ſaline compound, the principles of which are ſtrictly united, and very difficultly ſeparable. This truth has been illuſtrated by numerous and accurate experiments on this ſubject by Mr. Bourdelin, related in the Memoirs of the Academy for the years 1753 and 1755.

From theſe experiments we find, that ſedative ſalt reſiſts the moſt powerful agents for the decompoſition of ſaline ſubſtances. It was unaltered by treatment with inflammable matters, with ſulphur, with mineral acids diſengaged, or united with metallic ſubſtances, and with ſpirit of wine. Mr. Bourdelin could only perceive ſome marks of an inflammable matter, and a little marine acid, in this ſalt. The former he diſcovered by a ſmell of ſulphureous acid communicated by it to vitriolic acid; and the latter by a white precipitate formed in a ſolution of mercury, by the liquor obtained from the diſtillation of a mixture of this ſalt with powder of charcoal. Mr. Bourdelin does not poſitively affirm the laſt propoſition; but acknowledges, with all chemiſts, that we do not know the nature of ſedative ſalt, from not having been able to decompoſe it.

As this ſalt has the property of diſengaging the acids of nitre and of common ſalt by uniting with their baſes, and alſo as it is very vitrifiable, and promotes

motes the vitrification of other ſubſtances, moſt chemiſts believe that it is compoſed of vitriolic acid intimately combined with a fuſible and vitreſcible earth.

This is one of the ſalts which are ſoluble in ſpirit of wine, to the flame of which it communicates a green color. As only the ſaline combinations of copper are known to be capable of giving this color to the flame of ſpirit of wine, ſome chemiſts have been induced to believe, that ſedative ſalt might contain copper, or the calx of copper.

Laſtly, we may ſuſpect ſome analogy betwixt the ſedative ſalt, on one ſide, and arſenic and phoſphoric acid on the other, from ſome properties which each of theſe ſubſtances have, and particularly from their action upon certain ſalts, and from their vitreſcible quality. But theſe latter ſubſtances are not better known than ſedative ſalt; therefore all that we can ſay upon this ſubject is, that much yet remains to be diſcovered concerning all theſe matters.

Excepting the uſes of borax in vitrifications, and in fuſions and ſoldering of metals, ſedative ſalt is only employed in medicine. Homberg, its inventor, believed that he diſcovered in it a ſedative, antiſpaſmodic, and even narcotic quality, and thence called it the *narcotic ſalt of vitriol.*

It was generally employed in convulſive diſeaſes after the praiſes Homberg had beſtowed upon it; but its ſedative powers have not been well aſcertained. The beſt practitioners even affirm, that, to produce any effect, it muſt be given from half a gros to a gros, inſtead of doſes of a few grains, which were given at firſt. *See* BORAX. *(t)*

SALT *of* SODA.

This is one of the names given to marine or mineral alkali obtained from the aſhes of ſoda and of other maritime plants. *See* ALKALI (MINERAL).

SULPHUREOUS SALT *of* STAHL.

This name is given to a neutral ſalt, compoſed of volatile ſulphureous acid, combined to the point of ſaturation with fixed vegetable alkali.

(t) SEDATIVE SALT. Mr. Cadet has publiſhed, in the Memoirs of the Royal Academy of Sciences for the year 1766, an account of ſome experiments made by him upon borax and the ſedative ſalt. From theſe he infers, 1. that the acid contained in borax is the marine, he having made a corroſive ſublimate with this acid and the mercurius precipitatus per ſe. 2. That the ſedative ſalt does not exiſt in borax, but is produced during the proceſs. 3. That this ſedative ſalt is compoſed of the marine acid originally exiſting in the borax, of the vitriolic acid employed in the operation, and of a vitreſcible earth. 4. That this vitreſcible earth is the ſame as that which is generally ſeparated from borax during its ſolution in water, and which abounds more in the unrefined than in the refined borax. 5. That this earth conſiſts of a calx of copper, from which by reduction he obtained a regulus of copper. 6. That borax therefore is compoſed of a calx of copper united with marine acid, and with mineral alkali. The ſame chemiſt purpoſes to make further experiments on this ſingular ſalt.

This

This salt may be made either by saturating fixed alkali with volatile sulphureous acid made in a cracked retort, in Stahl's manner, or by exposing linen soaked in liquid fixed alkali to the vapors of sulphur slowly burning. When this latter method is employed, the linen dries, becomes stiff, and shines with many small, needle-like crystals, which are the sulphureous salt.

Volatile sulphureous acid does not differ from pure vitriolic acid but by a portion of phlogiston, which is only weakly united with it, but is however sufficient to disguise considerably the essential properties of this acid. Sulphureous vitriolic acid has not only a pungent smell and volatility which the pure vitriolic has not, but it also forms with different substances, particularly with fixed alkali, neutral salts very different from those formed by the union of these substances with pure vitriolic acid. Stahl first observed this salt, which is the only one known of all the combinations of the sulphureous acid.

This sulphureous salt has a more pungent taste than vitriolated tartar, is more soluble in water, and is crystallizable by cold. Its crystals are like needles attached to each other by their ends, forming tufted clusters of crystals; in which respect also it differs from vitriolated tartar, and is somewhat analogous to nitre.

This salt may be decomposed by any acid, and its sulphureous acid expelled from it. Thus vitriolic acid, from being naturally the strongest of any, is rendered the weakest of all, merely by union with the inflammable principle, which is only weakly combined with it.

The natural volatility of the phlogistic principle, and its weak adhesion to the volatile sulphureous acid, occasion a gradual change of the nature of the sulphureous salt. This salt is perpetually changing, from the constant dissipation of its phlogiston. It gradually loses its peculiar properties by which it differs from vitriolated tartar, becomes more and more similar to this salt, and at last, when it has lost all its phlogiston, does not in any respect differ from it. Probably we might observe the same changes in the combinations of sulphureous acid with other substances; nevertheless those which, like metals, have a stronger affinity with phlogiston than alkali has, may perhaps produce effects very different.

All the phenomena of the sulphureous salt, of the volatile sulphureous acid, and of sulphur, with regard to their several combinations, are naturally deducible from this general principle, that the affinities of the most compound bodies are always weaker than those of the most simple substances. *See* VOLATILE SULPHUREOUS ACID, *and* ACID (VITRIOLIC).

FEBRIFUGAL SALT *of* SYLVIUS.

This is a neutral salt composed of marine acid saturated with fixed vegetable alkali. It is also called *regenerated sea salt*, but improperly, because the basis is different from that of sea salt. Excepting its taste, which is not so agreeable as that of sea salt, it resembles this salt in its crystallization, and in most of its essential properties. It does not seem to deserve the epithet *febrifugal*, although it may, when given in proper doses as a purgative and antiseptic, contribute

contribute to the cure of some fevers, which qualities are common to it with other neutral salts. It is not now employed. *See* ACID (MARINE), ALKALI (FIXED), *and* NEUTRAL SALTS.

SALTS *of* TAKENIUS.

The salts prepared in Takenius's manner are impure fixed alkalis, obtained from the ashes of vegetables burnt for that purpose in a peculiar manner, namely, by suffocating their flame, and leaving no more communication with the air than is sufficient for the burning of their most disengaged inflammable parts.

When therefore we would prepare the fixed salts of a plant according to this method, the dried plant is put in an iron pot, which is to be heated so that its bottom shall be red. The plant must be continually stirred; a thick fume will exhale from it, and at length a flame rises. The pot is then to be covered with a lid, which must be so loose that the flame only will be extinguished, and the smoke will pass out. The lid must be taken off sometimes, that the plant may be stirred. When the plant is by this method reduced to a kind of ashes, these ashes must be lixiviated with boiling water; and when the lixivium has been evaporated to dryness, a saline matter more or less reddish will remain, which ought to be kept in a bottle. This is the fixed salt of the plant prepared in Takenius's method.

By burning plants in this manner, the fixed alkali obtained is evidently phlogisticated, rendered semi-saponaceous, similar to that which is prepared for the making of Prussian blue, and mixed with all the neutral salts contained in the plant. These impure alkalis have been intended only for medicinal uses. Some persons have imagined that they could retain much of the virtue of the plant from which they have been obtained. But although we do not doubt that the fixed salts of different plants, prepared in this method, differ considerably from each other; yet as the medicinal virtues of vegetables depend chiefly on their proximate principles, and as these principles are totally changed, and decomposed by burning, even when they are made with the precautions which Takenius mentions, these salts retain none of the virtues of the plants from which they are produced when alkalis are required. They are only semi-saponaceous fixed alkalis, much less caustic than well purified alkalis, and which therefore may be preferred in medicine. These alkalis partake besides of the virtues of the neutral salts with which they are mixed.

SALT *of* TARTAR.

This name is commonly given to the fixed alkali of tartar, and even frequently to fixed vegetable alkali in general. *See* ALKALI (FIXED).

VEGETABLE SALT.

This salt, called also *soluble tartar*, and *tartarised tartar*, is a combination to the point of saturation of cream of tartar, or acid of tartar with fixed vegetable

table alkali. It is prepared and cryſtalliſed like ſalt of Saignette, from which it differs in its alkaline baſis. The cryſtals of this ſalt are much ſmaller than thoſe of ſalt of Saignette. In other reſpects it has the ſame properties, chemical and medicinal. *See* SALT *of* SAIGNETTE, TARTAR, *and* TARTAR (SOLUBLE).

SALT *of* VINEGAR.

The ſalt ſold by apothecaries under this name is nothing but vitriolated tartar, impregnated with very ſtrong radical vinegar.

As pure radical vinegar cannot be obtained in a concrete ſtate but with very great difficulty, and as it does not retain this concrete ſtate when it has once received it, as the Count de Lauraguais has ſhewn, when a ſalt of vinegar is required with a very pungent and penetrating ſmell, to be kept in bottles, like the concrete volatile alkali called ſalt of England, a better expedient has not been found than that we have mentioned. This mixture has a ſmell of radical vinegar, almoſt as pungent as that of volatile alkali, although the kind be very different; and is applicable to the ſame purpoſes, namely, to relieve hyſterical paroxyſms. *See* VINEGAR.

VOLATILE SALTS.

This name is frequently given to volatile concrete alkaline ſalts. Thus *volatile ſal ammoniac*, and *volatile ſalt of hartſhorn*, are the volatile alkalis obtained from theſe ſubſtances. Nevertheleſs, the ſame name is ſometimes given to other ſaline ſubſtances of very different natures, for inſtance, *the ſalt of amber*, which is acid, and is called *volatile ſalt of amber*, which is certainly an inconvenience. The appellation *volatile ſalt* may be given to all ſaline matters really volatile, that is, which may be ſublimed with a moderate heat. But as theſe ſalts are of very different kinds, they ought to be diſtinguiſhed by ſome more particular name. The volatility of ſalts is a very indeterminate quality. For of thoſe which are conſidered as ſuch, ſome are much more, and ſome much leſs volatile than others.

Theſe ſalts are called *ſemi-volatile* which cannot be ſublimed without a fire ſufficient to render the bottom of the veſſel containing them red-hot, ſuch as moſt ammoniacal ſalts, ſweet mercury, and ſome others. And thoſe are called *fixed ſalts* which may be kept red-hot during a certain time without ſenſible loſs. But, rigorouſly ſpeaking, no ſalts are abſolutely fixed; for, as we have ſaid elſewhere, the alkalis called fixed, and the other ſalts which are conſidered alſo as fixed, are diſſipated in fume when long expoſed to violent fire, with acceſs of air. *See* ALKALIS (VOLATILE), FIXITY, VOLATILITY.

URINOUS SALTS.

This name was given by ancient chemiſts to all alkaline ſalts, volatile or fixed; to the former, becauſe they all have the taſte of putrefied or diſtilled urine;

urine; and to the fixed, becauſe although they have not themſelves this taſte, they however occaſion it, when applied to the tongue, by diſengaging the volatile alkali contained in animal ſubſtances. Therefore *urinous ſalts* and *alkaline ſalts* are ſynonimous. *See* ALKALI.

SALT *of* STEEL.

Some chemiſts have given this name to ſeveral combinations of iron with acids, even to martial vitriol, as appears from *Riverius's ſalt of ſteel*, which is a martial vitriol made with iron, vitriolic acid, and ſpirit of wine. *See* VITRIOL.

DCIX. SALT-PETRE. *See* NITRE.

DCX. SAND. Sand is compoſed of ſmall ſtoney matters. The kinds of ſand may therefore be as many as the kinds of ſtones. Moſt ſands conſiſt of different kinds of ſtones mixed together. But as ſoft ſtones are eaſily reducible into ſo ſmall particles, that they are more like powders or earths than ſand; and as the molecules of hard or vitrifiable ſtones are capable of preſerving longer their ſize; hence moſt matters called ſand are of the nature of vitrifiable earths. *See* EARTHS (VITRIFIABLE). Accordingly, by the name of ſand, we underſtand always, in natural hiſtory and in chemiſtry, a matter of the nature of vitrifiable earths.

The principal uſe of ſand in chemiſtry is in compoſitions for pottery and glaſs. Some ſands are more and ſome leſs fuſible. The particles alſo of ſome are larger than thoſe of others. The finer kind is generally uſed for vitrifications, and other chemical operations, becauſe it is naturally much divided: It is frequently employed to make a *ſand-bath* to tranſmit heat to veſſels placed in it.

DCXI. SANDARACH. This is a yellow or red combination of arſenic with ſulphur. *See* ARSENIC, *and* REALGAR.

DCXII. SANDIVER. *See* GLASS-GALL.

DCXIII. SAPHIRE. *(u)*

DCXIV. SARCOCOLLA. *(x)*

DCXV. SARSAPARILLA. *(y)*

DCXVI. SASSAFRAS. *(z)*

(u) SAPHIRE is the name of a pellucid blue gem, the hardneſs of which is next to that of the ruby. By fire it is unfuſible, but its color is thereby deſtructible. It may be imitated by fuſing a hundred parts of cryſtal-glaſs-fritt with one part of zaffre, and a very ſmall proportion of manganeſe.

(x) SARCOCOLLA is a gum-reſin, of an ounce of which ſix drams were found to be ſoluble by ſpirit of wine; and ſeven drams and a half were found to be ſoluble by water. *Neuman.*

(y) SARSAPARILLA. From ſixteen drams of this root Neuman obtained by water ſix drams of gummy extract, and from an equal quantity he obtained by ſpirit four drams of reſinous extract.

(z) SASSAFRAS. The wood of this tree contains the heavieſt of all known eſſential oils. Of this oil Hoffman obtained an ounce and ſix drams from ſix pounds of the wood; and Neuman obtained from an equal quantity of wood, two ounces. From an ounce of ſaſſafras four ſcruples of extract were obtained by means of rectified ſpirit; and from an equal quantity of the wood, two drams were extracted by water. *Neuman.*

DCXVII. SATURATION. All the particles of matter have, as is ſaid under the articles AFFINITY, COMBINATION, SOLUTION, *and* GRAVITY, a tendency to unite one with another. In fact, when they are united, and when this tendency is ſatisfied, it is called the ſtate of *ſaturation*, and then the whole effect of this tendency, or of this force, conſiſts in making them cohere together. But all the phenomena of chemiſtry ſhow, that the tendency to union of the parts of different ſubſtances is more or leſs ſtrong, according to the nature of theſe ſubſtances. Hence the parts of two ſubſtances may be united together with all the force of which they are ſuſceptible, reſpectively to each other, although their tendency to union in general be very far from being entirely exhauſted and ſatisfied.

This remark leads us to conſider ſaturation in two views, that is, that we ſhould diſtinguiſh the ſaturation of one ſubſtance relatively to another, from the greater or leſs diminution of tendency to union in general, which a ſubſtance has ſuſtained by means of any particular union contracted. This latter we ſhall call *abſolute ſaturation*, and the former *relative ſaturation.*

Theſe things being premiſed, as the general tendency to union diminiſhes always in proportion to the force with which the parts are united, hence the adheſion, more or leſs ſtrong, contracted betwixt the principles of any compound, influences much the nature and eſſential properties of this compound; for example, when the principles of a body are capable of uniting together with all their general tendency to union, their relative ſaturation is then confounded with their abſolute ſaturation, ſo that after their union, no tendency to new unions can be perceived in theſe bodies, or in any of their principles. Such are the neutral ſalts compoſed of mineral acids and fixed alkali. So ſtrong an union is contracted by the acid and alkaline principles of theſe ſalts, that they loſe entirely, or almoſt entirely, their taſte, cauſticity, activity; in a word, all the properties which before this union were occaſioned by their general tendency to combination. Accordingly, the relative ſaturation of theſe is very diſtinct, and is one of the firſt which has been obſerved.

When, on the contrary, the principles of a compound can contract together only a weak union, and conſequently do not exhauſt by this union all their general tendency to combination, not only their point of relative ſaturation is leſs diſtinct, but alſo theſe principles, although relatively ſaturated by each other, are far from abſolute ſaturation, and ſtill preſerve, notwithſtanding this union, much of their diſſolving power. Compounds of this kind are always conſiderably active, and even cauſtic according to the nature of their principles. Such are deliqueſcent ſalts, and particularly moſt ſalts compoſed of mineral acids and metallic ſubſtances, the cauſticity of which cannot be otherwiſe explained. *See the articles* CAUSTICITY, *and* SUBLIMATE (CORROSIVE).

Many ſubſtances have a determinate and conſiderably diſtinct point of relative ſaturation, altho' they contract together but a weak union. But if we attend, we ſhall perceive that all theſe ſubſtances poſſeſs but a ſmall quantity of diſſolving power, or a weak general tendency to combination. Their relative ſaturation is nearly equal to their abſolute ſaturation. Such are ether with water, eſſential oils with ſpirit of wine, and moſt neutral ſalts with water. If we mix together and agitate good ether with water, a part of the ether unites with

with the water, nearly in the proportion of one to ten; ſo that if one part of ether be added to ten parts of water, all the ether diſappears by being diffuſed through the water, as the Count de Lauraguais obſerves. If the quantity of ether be more than one tenth part of the water, the overplus will float diſtinct upon the ſurface of the water, like an oil.

Alſo well rectified ſpirit of wine can only diſſolve a determinate quantity of each kind of eſſential oil, which quantity varies according to the kind of oil, and to the ſtate in which it happens to be. In general, the more attenuated they have been by rectification, the more they are removed from a reſinous ſtate, and the ſmaller quantity of them is ſoluble. And alſo the more highly rectified a ſpirit of wine is, the larger quantity of oil it diſſolves.

Water is the proper ſolvent of neutral ſalts. It is capable of diſſolving any of them, but moſt of them only in a certain quantity: and this point of ſaturation of water differs with different ſalts, and degrees of heat applied. The point of ſaturation is moſt diſtinct with thoſe ſalts which contain a ſmall quantity only of the water of cryſtallization, and which are nearly equally ſoluble in hot and in cold water. Such are vitriolated tartar, and, ſtill more, common ſalt.

When the water is once ſaturated with theſe kinds of ſalts, the ſtrongeſt and longeſt boiling does not diſſolve a grain more, and the overplus of the ſalt remains entire at the bottom of the boiling water: But boiling water diſſolves an equal, or even an unlimited quantity of ſome ſalts, chiefly of thoſe which contain much water in their cryſtallization, ſuch as Glauber's ſalt, alum, borax, martial and cupreous vitriols, and others of that kind. The water of cryſtallization of theſe ſalts is alone ſufficient to keep them diſſolved, by means of heat. Hence, when they are expoſed to fire without water, they ſuffer a liquefaction, which is very different from fuſion, and is nothing elſe than a ſolution of the ſalt in the water of its cryſtallization, and conſequently laſts only till this water be evaporated. The point of ſaturation of water for theſe ſalts ſeems to be indeterminate.

Many ſubſtances are capable of uniting without being preciſely ſaturated, ſuch as water with any of the following ſubſtances; fluor acids, fixed vegetable alkali, fluor volatile alkali, moſt of the very deliqueſcent neutral ſalts, and ſpirit of wine. Such alſo are almoſt all metals uniting with each other: Although many of theſe ſubſtances have a great affinity together, as the fluor acids and alkalis with water, yet all their general tendency to combination is not exhauſted in theſe kinds of union. On the contrary, their union is little elſe than a very accurate and intimate mixture. Their diſſolving power is not ſatisfied by ſuch an union, but is almoſt entirely preſerved. We need not therefore be ſurpriſed, that no preciſe or determinate point of ſaturation is obſerved betwixt theſe ſubſtances. We may ſay, in general, that the point of relative ſaturation is ſo much more exact, diſtinct, and determinate, as the bodies which unite together have a ſtronger affinity, as they more compleatly exhauſt upon each other their diſſolving power, or as their relative ſaturation is more nearly equal to their abſolute ſaturation.

The examination of the ſeveral degrees of ſaturation which ſubſtances may ſuſtain by combining together, is an object as important as it is new in chemiſtry. This matter has been ſcarcely begun, and yet it well deſerves the attention of chemiſts, as it would greatly advance the ſcience. We could not

treat

treat this ſubject more fully without repeating what has been ſaid elſewhere. We therefore refer to the articles *affinity*, *combination*, *compoſition*, *ſolution*, *cauſticity*, *gravity*, *ſalts*, *neutral ſalts*, *corroſive ſublimate*; and ſeveral others.

DCXVIII. SAUNDERS. (*a*)

DCXIX. SCAMMONY. (*b*)

DCXX. SCORDIUM. (*c*)

DCXXI. SEA-WATER. *See* WATER.

DCXXII. SELENITES. Modern chemiſts give this name to a ſort of neutral ſalt formed by the union of vitriolic acid with any calcareous earth. Vitriolic acid and calcareous earth are capable of combining together to the point of ſaturation in the moſt intimate manner. Probably a very conſiderable quantity of earth enters into this combination, at leaſt if we judge of it by the ſaturation of vitriolic acid, which appears to be more compleat than in any of the other neutral ſalts formed with this acid. This truth is ſufficiently eſtabliſhed by the properties of ſelenites.

Nature furniſhes us with a very large quantity of ſelenitic matters. Chemiſts agree that all gypſums or plaſter-ſtones, alabaſters, and gypſeous ſpars, are nothing elſe than ſelenites; but theſe ſubſtances are in large quantities within and upon the earth. We may alſo artificially compoſe ſelenites, by combining vitriolic acid to the point of ſaturation with calcareous earth. To effect this ſaturation eaſily, the calcareous earth muſt be in fine powder, the acid muſt be diluted in a very large quantity of water, and more earth muſt be added than is neceſſary for the ſaturation. Selenites may alſo be conveniently made by

(*a*) SAUNDERS. The wood of the tree, called *red ſaunders*, contains a red coloring material uſed in dying. Its color reſides wholly in a reſinous matter, and hence is extractable by ſpirit of wine, and not by water. The red color of Saunders, imparted to ſpirit of wine, becomes, by diluting the tincture with more ſpirit, yellow. The reſin gave a deep red color to oil of lavender, and a pale red to oil of almonds and to oil of aniſeeds, but no color to oil of amber and to oil of turpentine. The wood of the tree, called *yellow ſaunders*, is from its fragrance ſometimes employed as a perfume. From ſixteen ounces of the raſped wood, digeſted ſome days in ſalt water, two drams eſſential oil were obtained by cohobation. Two drams of gummy extract may be obtained from two ounces of the wood, by water; and from an equal quantity of wood, two drams and a half of reſinous extract may be obtained by rectified ſpirit. *Neuman.*

(*b*) SCAMMONY is a gummy-reſinous juice, which exſudes from the root of a ſpecies of convolvulus, in which inciſions are purpoſely made at a certain ſeaſon of the year. An ounce of Smyrna ſcammony yielded with water half an ounce of gummy extract, and the reſiduum yielded with ſpirit two drams of reſin, leaving two drams of impurities undiſſolved. By applying rectified ſpirit at firſt to an ounce of the ſame ſcammony, two drams and two ſcruples of reſinous extract were obtained; and from the reſiduum, water extracted half an ounce of gum, the indiſſoluble part amounting here to four ſcruples only. *Neuman.*

(*c*) SCORDIUM. An ounce of the dried leaves of ſcordium yielded with water four drams and a half of gummy extract, and afterwards with rectified ſpirit fifteen grains of reſin. Another ounce, treated firſt with ſpirit, gave three drams of reſinous extract, and afterwards with water, five ſcruples and a half of gum. A tincture, made in highly rectified ſpirit of wine, contains more of the active and leſs of the mucilaginous parts of this plant, than one made with a weaker ſpirit.

ſaturating

ſaturating lime-water gradually with weak vitriolic acid, or, laſtly, by pouring this acid into a ſolution of nitrous or marine ſalts with calcareous baſes. In theſe latter operations the ſelenitic ſalt renders the liquor turbid, and is precipitated.

Selenites, natural or artificial, when well waſhed from all exceſs of acid or other extraneous matter, has a ſlightly nauſeous taſte, which is ſcarcely perceptible but by drinking a glaſs of water impregnated with it, like that of the wells in and near Paris, the ſweetiſh and ſlightly nauſeous taſte of which is well known.

This earthy ſalt is one of the leaſt ſoluble by water of all the known neutral ſalts. Seven or eight hundred parts of water are required to diſſolve one part of ſelenites, excepting when its principles are combined, and the ſalt formed in the water, as Mr. Beaume has obſerved; for then the water may diſſolve four or five times as much. By a ſlow evaporation it cryſtallizes, and forms thin laminæ, and retains in its cryſtallization a very ſmall quantity of water.

When it is expoſed to a moderate fire, it eaſily loſes this water of its cryſtallization with its tranſparency and coheſion of its parts, and is reduced to a white powder.

With a very great fire, it is not fuſible when alone, *(d)* but is more eaſily fuſible than pure calcareous earth, by the addition of fluxes, as ſand, and clay, and vitrifying ſalts. It reſiſts the greateſt heat without loſing its acid. It cannot be decompoſed but by phlogiſton, by alkalis fixed or volatile; and by metallic ſolutions in nitrous acid, by means of a double affinity. Thus the ſolution of mercury readily ſhews whether a water be ſelenitic or not, by forming a precipitate of turbith mineral when added to ſuch waters. As ſelenitic matters are copiouſly diffuſed, and almoſt every where within the earth, moſt waters of wells, or rivers, contain a greater or leſs quantity of ſelenites diſſolved in them, as we may eaſily find by the abovementioned method of trial.

Nothing better ſhews the extreme difference betwixt vitriolic and other mineral acids, than the compariſon of the ſaline properties of ſelenites with thoſe of nitrous and marine ſalts with calcareous baſes. The earthy baſis is the ſame in theſe three ſalts; but the two latter have a violent, almoſt cauſtic taſte, and are ſurpriſingly deliqueſcent; while the firſt ſalt is very difficultly ſoluble in water, and almoſt inſipid. The cauſe of theſe differences is, that vitriolic acid is more ſimple than the other acids, and is therefore capable of being more intimately combined and ſaturated with calcareous earth.

This kind of ſalt has been called ſelenites probably becauſe naturaliſts found its ſaline properties ſo weak, that they thought it ought to be diſtinguiſhed from other neutral ſalts by a peculiar name. Perhaps they did not even believe it to be ſaline; for the nature of ſelenitic matters has been diſcovered but lately by experiments of modern chemiſts.

We are not yet enough acquainted with calcareous earths to know if ſelenites be of different kinds, or if all the ſubſtances to which this name is given are only one and the ſame ſalt under different forms of cryſtallization. If the kinds of calcareous earth be eſſentially different, they muſt form with vitriolic

(d) From Mr. D'Arcet's Memoir upon the effects of a violent and long continued heat, we find that all gypſeous ſtones, and alſo the artificial ſelenitic ſalts, are fuſible and vitreſcible by violent fire.

acid.

acid several kinds of selenites also essentially different from each other. But if only one kind of calcareous earth exists, then it can only form one kind of selenites.

We may observe, that amongst the various bodies called by chemists selenites, that is, compounds of vitriolic acid with calcareous earths, some differ much from others, at least externally. These substances are all the gypsums, alabasters, and spars, which some chemists, particularly Mr. Pott, have called gypseous, and, lastly, some crystallizations and stalactites, which have the same principles and the same essential properties as other selenitic substances. *See* ACID (VITRIOLIC), ALABASTER, GYPSUM, SPAR, *and* EARTH (CALCAREOUS).

DCXXIII. SEMI-METAL. Substances possessing all the metallic properties, excepting fixity and ductility, are called *semi-metals.* Thus every matter possessed of metallic density, opacity, and lustre, which is incapable of uniting with earths, but which is also brittle and frangible by the stroke of a hammer, and capable of being sublimed or reduced into vapors by fire, is a semi-metal. Hitherto we know but five semi-metals, which are *regulus of antimony, zinc, bismuth, regulus of cobalt, and regulus of arsenic.*

Some chemists have numbered mercury amongst the semi-metals, under pretence that it possessed all the metallic properties excepting fixity and ductility: but all semi-metals are combustible, and mercury is no more so than the perfect metals; and also, the want of ductility is falsely imputed to it, since the Academicians of Petersbourg, who some years ago fixed it, found it ductile and malleable. If mercury then be not ductile in its ordinary state, the cause of this appears to be, that it is really in fusion: but the most ductile metals lose their ductility by fusion, as this quality necessarily implies solidity. On the other side, the great volatility of mercury does not allow us to class it among metals. This metallic substance is therefore single in its kind, and is really neither a metal nor a semi-metal. *See* MERCURY.

Mr. Cronstedt has given, in the Memoirs of the Swedish Academy for the year 1751, a description of a new semi-metal: but this metallic substance is hitherto but little known. *(e)*

DCXXIV. SENA. *(f)*

(e) Concerning this new semi-metal discovered by Mr. Cronstedt, *see the article* NICKEL. *See also the note (y) to the article* METALS, concerning another new semi-metal which Mr. Justi says that he has discovered in the yellow mica.

(f) SENA. An ounce of the leaves of Sena, treated with fresh parcels of rectified spirit of wine, yielded two drams and twenty-three grains of resinous extract; and afterwards with water, two drams and two scruples of gummy extract, three drams and three grains remaining undissolved. Another ounce, treated first with water, gave four drams and half a scruple of gummy, and afterwards with spirit only, twenty-eight grains of a resinous extract, which appeared to contain some gross oily matter; and hence was difficultly reduced to dryness. The residuum weighed three drams and a scruple. Water distilled from Sena possesses the peculiar smell of these leaves, but no essential oil appears. The activity of Sena is greatly weakened by evaporation, especially if the process be performed in an open vessel with a boiling heat. *Neuman.*

DCXXV. SENEGAL (GUM) (g)

DCXXVI. SERPENTINE-STONE. (h)

DCXXVII. SILK. (i)

DCXXVIII SILVER. Silver, called alſo *luna* by chemiſts, is a perfect metal, of a ſhining white color.

Its ſpecific gravity is, although conſiderable, nearly one half leſs than that of gold. It loſes in water an eleventh part of its weight. A cubic foot of ſilver weighs 720 pounds.

The tenacity of its parts is alſo nearly one half leſs than that of gold; a ſilver wire, the diameter of which is $\frac{1}{10}$ part of an inch, can ſupport only a weight of 270 pounds without breaking.

This metal is, next to gold, the moſt ductile of all. Very fine wire and leaf may be formed of it.

It is ſomewhat ſonorous and harder than gold, as Juncker obſerves; and is fuſible with a leſs degree of heat than gold is, according to Cramer. It ſeems to be as fixed and indeſtructible as gold is. Kunckel kept ſilver and gold in a glaſs-houſe-furnace during a month without alteration, or more loſs than of a few grains, which probably proceeded from a ſmall quantity of extraneous matter, with which it was mixed.

Juncker nevertheleſs affirms, that ſilver may be changed into a vitreſcent calx, when treated by a long reverberation in the manner of Iſaacus Hollandus. This reverberation, conſiſts in expoſing metals, reduced into very fine parts, to the action of the ſtrongeſt heat they can ſuſtain without fuſion, with the contact of free air. This method is very effectual for burning the inflammable principle of metals and of all other bodies. But Juncker does not mention the author of this experiment.

The combined action of air and water does not alter the color and brilliancy of ſilver, nor occaſion any ruſt. Nevertheleſs, the ſurface of this metal is apt to tarniſh, and even to become black, by the contact of the phlogiſton of ſeveral inflammable matters, or of their exhalations; becauſe it has the property of impregnating itſelf with the inflammable principle ſuperabundantly, even in the cold, like ſome other metallic matters: but ſilver ſeems to be more ſuſceptible of this effect than any other metal.

All acids are, with more or leſs facility, capable of diſſolving ſilver.

Vitriolic and marine acids may be combined with ſilver in its metallic ſtate; but difficultly, and by particular management.

To diſſolve ſilver directly, vitriolic acid muſt be much concentrated and very hot; and therefore diſtillation is neceſſary, as in the operation of turbith mineral. *See* TURBITH MINERAL.

(g) SENEGAL (GUM) is a gum, almoſt pure, and entirely ſimilar in properties to the other pure gums, as gum arabic, cherry-tree and plumb-tree gums. *See* GUM.

(h) SERPENTINE STONE is a ſteatites variouſly colored, but in which the green color generally predominates. *See* STEATITES.

(i) SILK is an animal ſubſtance, from 16 oz. of which may be obtained, by diſtillation, nine ounces of mixed matters, containing four ounces and two drams of urinous ſpirit, three ounces ſix drams of volatile ſalt, and one ounce of empyreumatic oil. The caput mortuum weighed ſeven ounces, and loſt an ounce on being calcined to whiteneſs. By elixating the calx, forty grains of fixed ſaline matter were alſo obtained. *Neuman.*

The marine acid cannot attack ſilver directly; but when it is very much dephlegmated, and, as it were, in a dry ſtate, conſiderably hot and reduced to vapor, as is done by the royal cement in *concentrated parting*. *See* PARTING (CONCENTRATED).

But ſilver may be combined with the above-mentioned acids, by methods much more ſimple and convenient, which we ſhall deſcribe, after having ſpoken of the ſolution of ſilver by nitrous acid.

Nitrous acid, very pure and moderately ſtrong, diſſolves ſilver in its metallic ſtate with the greateſt facility. This ſolution is made ſpontaneouſly without heat, or with a very gentle heat at firſt; and when the ſilver has begun to diſſolve, the heat ought to be diſcontinued, to prevent the ſolution from being too violent, eſpecially if the quantities operated upon be conſiderable.

By this method nitrous acid may be ſaturated with ſilver; and if it be ſtrong, it will diſſolve a conſiderable quantity of that metal.

If the ſilver thus diſſolved be allayed with copper, the ſolution will be green, and will preſerve this color. If it contain no copper, the ſolution is at firſt greeniſh, which color gradually diſſipates, and at laſt the liquor becomes quite white.

The ſurface of the ſilver begins to become black as ſoon as the acid makes impreſſion upon it. This blackneſs proceeds from a part of the phlogiſton of the nitrous acid, which is applied ſuperabundantly to the ſurface of the ſilver.

Black flocks are frequently ſeen floating in this ſolution, which are inſoluble by nitrous acid, and precipitate to the bottom. Theſe flocks may be a ſmall quantity of gold from which ſilver is ſeldom entirely free, or of ſome other phlogiſticated ſubſtance, inſoluble in nitrous acid.

The ſolution of ſilver by nitrous acid is more acrid and corroſive than pure nitrous acid; which property is very remarkable, and is common to it with ſeveral other combinations of metals. *See an explanation of this property under the article* CAUSTICITY.

This ſolution of ſilver corrodes all vegetable and animal matters, and ſtains the ſkin of a black color, which cannot be effaced till the blackened part be abraded. This blackneſs can be only attributed to the phlogiſton of corroded matters, which unites ſuperabundantly with the ſilver of the ſolution employed.

If a ſolution of ſilver by nitrous acid be ſufficiently evaporated, and left to cool, a large quantity of white cryſtals will be formed in it, like ſcales, which are commonly called *cryſtals of ſilver*. Theſe cryſtals are a nitrous ſalt, the baſis of which is ſilver; for which reaſon it may alſo be called *nitre with baſis of ſilver*, or *lunar nitre*.

This ſalt is fuſible with a ſmall heat, and eaſily loſes the water of its cryſtalization. It becomes black, congeals by cold, and is capable of being moulded. It is then the famous cautery uſed by ſurgeons, and known by the name of *lapis infernalis*. *See the words* PARTING, CRYSTALS *of* SILVER, *and* LAPIS INFERNALIS.

Lunar nitre deflagrates upon coals almoſt as well as the nitre with baſis of fixed alkali, which ſhews a ſtrong adheſion of nitrous acid with ſilver. Nevertheleſs, this ſalt expoſed to ſtrong fire in diſtilling veſſels, or in a crucible, may be eaſily decompoſed. The acid quits the ſilver, and appears in its former ſtate.

Although

Although silver, as we have seen, is more easily soluble in nitrous acid than in vitriolic and marine acids, we ought not thence to conclude, that this metal has, with the nitrous acid, a greater affinity than with the two others. On the contrary, the two latter acids are capable of separating it from the nitrous acid, after this has dissolved it.

If vitriolic acid be poured into a solution of silver in nitrous acid, and if it be not diluted in too great a quantity of water, we see immediately the liquors become turbid, and a white precipitate appears, which is nothing else than a new combination made of the silver which quitted the nitrous acid to unite with the vitriolic acid, and to form with it a new salt with metallic basis. This salt which may properly be called *vitriol of silver*, or *lunar vitriol*, is crystallizable, and actually does crystallize in the very instant of precipitation; but the crystals are so small, from the rapidity of the crystallization, that they have only the appearance of a white powder. They cannot be discovered to be crystals but by means of a good magnifying glass.

The same event happens, if, instead of vitriolic acid, a solution of any salt containing that acid be added to a solution of silver in nitrous acid. The nitre of silver will be thereby decomposed, and a vitriol of silver obtained similar to the former.

Although vitriolic acid engaged in any basis, such as fixed alkali, with which it has a stronger affinity than with silver, does nevertheless quit its basis to combine with this metal, yet we may observe, that in these precipitations two decompositions and two new combinations are always effected, by means of a double affinity. We may therefore see the explanation of this case at the word AFFINITY.

Marine acid, whether engaged in any basis, or disengaged, produces in the solution of silver by nitrous acid the same effect as the vitriolic acid. It separates from the nitrous acid the metal, with which it unites and forms a new compound, or a *marine salt with basis of silver*, known to chemists by the name of *luna cornea*, or *corneous silver*. *See* LUNA CORNEA. It is called corneous, because this silver, united with marine acid by exposure to fire, may be melted; and may be coagulated by cold into a semi-transparent, semi-flexible mass, like horn.

Luna cornea, although in a saline state, is very little soluble by water. The precipitate which it forms is very apparent: it is composed of flocks, which adhere one to another, and form a kind of white curd, that floats in the liquor. By this appearance alone it may be distinguished from vitriol of silver.

These properties of a solution of silver, together with the facility with which it is rendered turbid by the presence of the smallest quantity of vitriolic and marine acids, disengaged or combined with any basis, render it very convenient and much used for the examination of waters, and in other chemical operations, to ascertain the presence of these two acids, in whatever compound they may be contained.

Silver, as well as all metals, may be separated from any acid by absorbent earths, or by fixed and volatile alkalis; and when afterwards fused, it recovers its original properties. Silver, thus dissolved, precipitated, and melted, is generally very pure. We may be certain that silver, which has been formed into

into luna cornea, and afterwards has been reduced, does not contain a particle of gold, platina, copper, iron, or other metallic ſubſtance ſoluble in aqua regia, and conſequently not ſeparable from nitrous acid by means of marine acid.

From what has been ſaid concerning theſe ſeveral decompoſitions of a ſolution of ſilver made by nitrous acid, we may infer that this combination may be decompoſed;

1. By the action of fire alone, which expels the nitrous acid.

2. By phlogiſton, which burns and deſtroys nitrous acid in the detonation of lunar nitre.

3. By precipitation with ſaline or earthy alkalis, which ſeize the nitrous acid, and leave the ſilver diſengaged in the ſtate of a precipitate.

4. By vitriolic acid, which ſeizes the ſilver, and leaves the nitrous acid diſengaged.

5. By marine acid, which has the ſame effect.

6. Laſtly, ſeveral metals, and eſpecially copper, having a ſtronger affinity than ſilver with nitrous acid, decompoſe alſo this ſolution of ſilver, by ſeizing the acid, and obliging the ſilver to ſeparate from it, which it does by precipitating it in its proper metallic ſtate. *See the words* Precipitate *and* Precipitation.

Sulphur diſſolves ſilver by fuſion, and forms with it a blackiſh maſs, which may be cut, and which has almoſt the color and conſiſtence of lead. It is called *ſulphurated ſilver*. This compound is a kind of artificial ore of ſilver. Some expert perſons are ſaid to be able to imitate very well by this mixture ſome natural ores of ſilver.

To make this combination, ſilver and ſulphur are laid alternately upon each other in ſeveral ſtrata in a crucible, which is to be heated by degrees till the whole be fuſed. Leſs heat is required for this fuſion than if the ſilver was alone, becauſe ſulphur facilitates the fuſion of this, as well as of all other metals difficultly fuſible, upon which it is capable of acting.

The ſulphur may be ſeparated from the ſilver by the mere action of the fire, continued during a certain time with acceſs of air. When ſulphurated ſilver is detonated with nitre, this ſeparation is very well and inſtantly made. As this metal is indeſtructible by all theſe agents, it is found to be unchanged by theſe operations.

Juncker relates, after Kunckel, that if ſulphur be diſſipated from ſulphurated ſilver by the action of fire; and if a volatile alkaline ſpirit of urine be poured upon this ſilver, a blue color is produced. He adds alſo, that this does not happen a ſecond time to the ſame ſilver, unleſs it be firſt cupelled with lead. This chemiſt concludes from thence, that this color proceeds from copper which the ſilver receives from the lead. *See Conſpectus Chymiæ, Tom.* I. *p.* 893.

Silver is found within the earth in different ſtates. A very ſmall quantity of it is in its natural and malleable ſtate, allayed with copper and gold; and is then called *virgin* or *native ſilver*: but ſilver is generally found in a mineral ſtate, that is, united and incorporated with heterogeneous matters, ſuch as other metallic ſubſtances, and the mineraliſing ſubſtances, namely, ſulphur and arſenic. It is ſeparated from all theſe matters by particular proceſſes practiſed both in eſſays and in ſmelting the ore in large quantities. *See* Ores *of* Silver.

Silver

Silver is purified from the allay of other destructible metals by treating it with nitre, or with lead. The latter method is generally used by refiners, and is called *cupellation*, or *refining*. *See* Refining.

All these operations are founded in general upon the destructibility of imperfect metals, and on the indestructibility of silver, which is a perfect metal: but as gold is an indestructible metal, all the purifications of silver, which are only effected by the destruction of metals allayed with it, are insufficient to separate it from gold. We must therefore have recourse to other operations for the separation of these two metals from each other. These operations, which are called by the general name of *parting*, are founded upon the property which silver has of being soluble by many menstrua which do not act upon gold. These menstrua are;

1. Nitrous acid, which dissolves silver without touching gold. By means of this acid, silver is generally parted from gold, and the operation is called *parting*, without any epithet to distinguish it from the others. *See* Parting.

2. Marine acid, which being applied conveniently to a mixture of gold and silver, seizes this latter metal exclusively of the former. As this parting is performed by cementation, and as the marine acid must be highly concentrated, it is called concentrated parting. *See* Parting (Concentrated).

3. Lastly, sulphur, which unites also to silver without touching gold, furnishes a third method of separating these two metals. This is called *dry parting*, because it is made by fusion, which chemists call the *dry way*. *See* Parting (Dry).

Silver is capable of being allayed with all metals, and forms with them different compounds, the properties of which may be seen under the word Allay.

According to Mr. Geoffroy's table of affinities, those of silver are first to lead, and then to copper, and Mr. Gellert's table mentions only gold.

DCXXIX. SIMILOR. This is a name given to an allay of red copper and zinc, made in the best proportions to imitate the color of gold. *See* Copper, Brass, *and* Zinc.

DCXXX. SMALT Is a blue glass composed of the calx of cobalt, vitrified and melted with some fritt of glass or crystal. Ground smalt is called *azure*, or *enamel blue*. *See* Azure, Cobalt, *and* Zaffre.

DCXXXI. SMELTING *of* ORES. We have shewn, under the articles *ores* and *pyrites*, the nature of the principal metallic minerals, and the substances of which they are composed. We have also explained, under the article *essay of ores*, the processes by which an exact analysis of these compound minerals may be made, and the nature and quantity of the contained metals may be known. In order to compleat what relates to this important subject, we shall describe in this article the principal operations by which are obtained "in the great," as it is called, or for commercial purposes, metals, sulphur, vitriols, and other useful substances contained in metallic minerals: What we shall say upon this subject will chiefly be extracted from a *Treatise on the Smelting of Ores, by Schlutter*, translated from the German into French by *M. Hellot*; because this, of all the modern works upon that subject, appears to be the most exact. We shall first describe the operations upon pyritous matters for the extraction of sulphur, vitriols, and alum; and afterwards the operations by which metallic

metallic ſubſtances are extracted from ores properly ſo called; from which alſo are occaſionally obtained the ſame matters as from the pyrites. As the preſent article is only the ſequel of the articles *ores*, *pyrites*, and *eſſays of ores*, it is evident that theſe articles ought to be read previouſly to this.

EXTRACTION *of* SULPHUR *from* PYRITES *and other* MINERALS.

In order to obtain ſulphur from pyrites, this mineral ought to be expoſed to a heat ſufficient to ſublime the ſulphur, or to make it diſtill in veſſels, which muſt be cloſe, to prevent its burning.

Sulphur is extracted from pyrites at a work at *Schwartzemberg*, in *Saxony*, in the high country of the mines; and in *Bohemia*, at a place called *Alten-Sattel*.

The furnaces employed for this operation are oblong, like vaulted galleries; and in the vaulted roofs are made ſeveral openings. Theſe are called *furnaces for extracting ſulphur*. See PLATE II. *Fig* 9.

In theſe furnaces are placed earthen-ware tubes, filled with pyrites broken into pieces of the ſize of ſmall nuts. Each of theſe tubes contains about fifty pounds of pyrites. They are placed in the furnace almoſt horizontally, and have ſcarcely more than an inch of deſcent. The ends, which come out of the furnace five or ſix inches, become gradually narrower. Within each tube is fixed a piece of baked earth, in form of a ſtar, at the place where it begins to become narrower, in order to prevent the pyrites from falling out, or choaking the mouth of the tube. To each tube is fitted a receiver, covered with a leaden plate, pierced with a ſmall hole to give air to the ſulphur. The other end of the tube is exactly cloſed A moderate fire is made with wood, and in eight hours the ſulphur of the pyrites is found to have paſſed into the receivers

The reſiduum of the pyrites, after the diſtillation, is drawn out at the large end, and freſh pyrites is put in its place From this reſiduum, which is called *burnings of ſulphur*, vitriol is extracted; as we ſhall preſently relate.

The eleven tubes into which were put, at three ſeveral diſtillations, in all nine quintals, or 900 pounds of pyrites, yield from 100 to 150 pounds of crude ſulphur, which is ſo impure as to require to be purified by a ſecond diſtillation.

This purification of crude ſulphur is alſo done in a furnace in form of a gallery, in which five iron cucurbits are arranged on each ſide. Theſe cucurbits are placed in a ſloping direction, and contain about eight quintals and a half of crude ſulphur. To them are luted earthen tubes, ſo diſpoſed as to anſwer the purpoſe of capitals. The noſe of each of theſe tubes is inſerted into an earthen pot, called the *fore-runner*. This pot has three openings; namely, that which receives the noſe of the tube; a ſecond ſmaller hole, which is left open to give air; and a third in its lower part, which is ſtopped with a wooden peg. *See* PLATE II. *Fig*. 10.

When the preparations are made, a fire is lighted about ſeven o'clock in the evening, and is a little abated as ſoon as the ſulphur begins to diſtill. At three o'clock in the morning, the wooden pegs, which ſtop the lower holes of the fore-

fore-runners, are for the first time drawn out, and the sulphur flows out of each of them into an earthen pot with two handles placed below for its reception. In this distillation the fire must be moderated and prudently conducted; otherwise less sulphur would be obtained, and it also would be of a grey color, and not of the fine yellow which it ought to have when pure. The ordinary loss in the purification of eight quintals of crude sulphur is, at most, one quintal.

When all the sulphur has flowed out, and has cooled a little in the earthen pots, it is cast into moulds made of beech tree, which have been previously dipt in water, and set to drain. As soon as the sulphur is cooled in the moulds, they are opened, and the cylinders of sulphur are taken out and put up in casks. These are called *roll-brimstone*.

As sulphur is not only in pyrites, but also in most metallic minerals, it is evident that it might be obtained by works in the great from the different ores which contain much of it, and from which it must be separated previously to their fusion: but as sulphur is of little value, the trouble of collecting it from ores is seldom taken. Smelters are generally satisfied with freeing their ores from it, by exposing them to a fire sufficient to expell it. This operation is called *torrefaction*, or *roasting of ores*.

There are, however, ores which contain so much sulphur, that part of it is actually collected in the ordinary operation of roasting, without much trouble for that purpose. Such is the ore of *Ramelsberg*, in the country of *Hartz*.

This ore, which is of lead, containing silver, is partly very pure, and partly mixed with cupreous pyrites and sulphur; hence it is necessary to roast it.

The roasting is performed by laying alternate strata of ore and wood upon each other in an open field, taking care to diminish the size of the strata as they rise higher; so that the whole mass shall be a quadrangular pyramid truncated above, whose base is about thirty-one feet square. Below, some passages are left open, to give free entrance to the air; and the sides and top of the pyramid are covered over with small ore, to concentrate the heat and make it last longer. In the center of this pyramid there is a channel, which descends vertically from the top to the base. When all is properly arranged, ladle-fulls of red-hot scoria from the smelting furnace are thrown down the channel, by which means the shrubs and wood, placed below for that purpose, are kindled, and the fire is from them communicated to all the wood of the pile, which continues burning till the third day. At that time the sulphur of the mineral becomes capable of burning spontaneously, and of continuing the fire after the wood is consumed.

When this roasting has been continued fifteen days, the mineral becomes greasy, that is, it is covered over with a kind of varnish: twenty or twenty-five holes, or hollows, are then made in the upper part of the pile, in which the sulphur is collected. From these cavities the sulphur is taken out thrice every day, and thrown into water. This sulphur is not pure, but crude, and is therefore sent to the manufacturers of sulphur to be purified in the manner above related. *See* PLATE II. *Fig.* 11. *and* 12.

As this ore of Ramelsberg is very sulphureous, the first roasting, which we are now describing, lasts three months; and during this time, if much rain has

has not fallen, or if the operation has not failed by the pile falling down or cracking, by which the air has so much free accefs, that the fulphur is burnt and confumed, from ten to twenty quintals of crude fulphur are by this method collected.

The fulphur of this ore, like that of moft others, was formerly neglected, till, in the year 1570, a perfon employed in the mines, called Chriftopher Sander, difcovered the method of collecting it, nearly as it is done at prefent.

Metallic minerals are not the only fubftances from which fulphur is extracted. This matter is diffufed in the earth in fuch quantities, that the metals cannot abforb it all. Some fulphur is found quite pure, and in different forms, principally in the neighbourhood of volcanos, in caverns, and in mineral waters. Such are the opake kind called *virgin fulphur*, the tranfparent kind called *fulphur of Quito*, and the native flowers of fulphur, as thofe of the waters of Aix-la-Chapelle. It is alfo found mixed with different earths. Here we may obferve, that all thofe kinds of fulphur which are not mineralifed by metallic fubftances, are found near volcanos, or hot mineral waters, and confequently in places where nature feems to have formed great fubterranean laboratories, in which fulphureous minerals may be analyfed and decompofed, and the fulphur feparated, in the manner in which it is done in fmall in our works and laboratories. However that be, certainly one of the beft and moft famous fulphur-mines in the world is that called *Solfatara*. The Abbé Nollet has publifhed, in the Memoirs of the Academy, fome interefting obfervations upon this fubject, which we fhall here abridge.

Near Puzzoli, in Italy, is that great and famous mine of fulphur and alum called at prefent *Solfatara*. It is a fmall oval plain, the greateft diameter of which is about 400 yards, raifed about 300 yards above the level of the fea. It is furrounded by high hills and great rocks, which fall to pieces, and whofe fragments form very fteep banks. Almoft all the ground is bare and white, like marle, and is every where fenfibly warmer than the atmofphere in the greateft heat of fummer; fo that the feet of perfons walking there are burnt through their fhoes. It is impoffible not to obferve the fulphur there; for every where may be perceived by the fmell a fulphureous vapor, which rifes to a confiderable height, and gives reafon to believe that there is a fubterraneous fire below, from which that vapor proceeds.

Near the middle of this field there is a kind of bafon three or four feet lower than the reft of the plain, in which a found may be perceived when a perfon walks on it, as if there were under his feet fome great cavity, the roof of which was very thin. After that, the lake Agnano is perceived, whofe waters feem to boil. Thefe waters are indeed hot, but not fo hot as boiling water. This kind of ebullition proceeds from vapors which rife from the bottom of the lake, which being fet in motion by the action of fubterraneous fires, have force enough to raife all that mafs of water. Near this lake there are pits, not very deep, from which fulphureous vapors are exhaled. Perfons who have the itch, come to thefe pits, and receive the vapors in order to be cured. Finally, there are fome deeper excavations, whence a foft ftone is procured which yields fulphur. From thefe cavities vapors exhale, and iffue out with noife, and which are nothing elfe than fulphur fubliming through the crevices. This fulphur adheres to the fides of the rocks, where it forms enormous maffes: in calm

weather

weather, the vapors may be evidently seen to rise 25 or 30 feet from the surface of the earth.

These vapors, attaching themselves to the sides of rocks, form enormous groups of sulphur, which sometimes fall down by their own weight, and render these places of dangerous access.

In entering the Solfatara, there are warehouses and buildings erected for the refining of sulphur.

Under a great shed, or hangar, supported by a wall behind, and open on the other three sides, the sulphur is procured by distillation from the soft stones we mentioned above. These stones are dug from under ground; and those which lie on the surface of the earth are neglected. These last are, however, covered with a sulphur ready formed, and of a yellow color: but the workmen say they have lost their *strength*, and that the sulphur obtained from them is not of so good a quality as the sulphur obtained from the stones which are dug out of the ground.

These last mentioned stones are broken into lumps, and put into pots of earthen ware, containing each about twenty pints, Paris measure. The mouths of these pots are as wide as their bottoms; but their bellies, or middle parts, are wider. They are covered with a lid of the same earth, well luted, and are arranged in two parallel lines along two brick walls, which form the two sides of a furnace. The pots are placed within these walls; so that the center of each pot is in the center of the thickness of the wall, and that one end of the pots overhangs the wall within, while the other end overhangs the wall without. In each furnace ten of these pots are placed; that is, five in each of the two walls which form the two sides of the furnace. Betwixt these walls there is a space of fifteen or eighteen inches; which space is covered by a vault resting on the two walls. The whole forms a furnace seven feet long, two feet and a half high, open at one end, and shut at the other, excepting a small chimney, through which the smoke passes.

Each of these pots has a mouth in its upper part without the furnace, in order to admit a tube of eighteen lines in diameter and a foot in length, which communicates with another pot of the same size placed without the building, and pierced with a round hole in its base of fifteen or eighteen lines diameter. Lastly, to each of these last mentioned pots there is a wooden tub placed below, in a bench made for that purpose.

Four or five of these furnaces are built under one hangar or shed. Fires are kindled in each of them at the same time; and they are thrown down after each distillation, either that the pots may be renewed, or that the residuums may be more easily taken out.

The fire being kindled in the furnace, heats the first pots containing the sulphureous stones. The sulphur rises in fumes into the upper part of the pots whence it passes through the pipe of communication into the external vessel. There the vapors are condensed, become liquid, and flow through the hole below into the tub, from which the sulphur is easily turned out, because the form of the vessel is that of a truncated cone, whose narrower end is placed below, and because the hoops of the tub are so fastened that they may be occasionally loosened. The mass of sulphur is then carried to the buildings mentioned before, where it is remelted for its purification, and cast into rolls, such as we receive it.

EXTRACTION *of* VITRIOL *from* PYRITES.

Sulphur is not the only substance procured from pyrites; for besides that, different kinds of vitriols and alum, according to the nature of the pyrites, are also extracted: so that pyrites may be considered as the ores of vitriols and alum as well as of sulphur.

These salts do not exist in the pyrites ready formed, as the sulphur does; but are, on the contrary, the products of the decomposition of pyrites, and are new combinations resulting from this decomposition. In the pale-yellow martial pyrites, this decomposition is effected without any other means than by exposure to moisture and air, and by the re-action of the sulphureous principle upon the iron which the pyrites contains, and with which the acid of the sulphur forms martial vitriol, as we may see under the article PYRITES. When the vitriol of this pyrites is to be extracted, this mineral is to be laid in a large heap three feet thick, and exposed to the air during three years, till it has entirely fallen into powder; and it is then to be stirred up every six months to accelerate the efflorescenee. The rain-water, which has washed it, is to be conducted into caldrons, into which old iron is thrown to saturate the superfluous acid. After this succeeds the evaporation and crystallization.

It is not necessary that the pyrites should fall into efflorescence for the extraction of vitriol. The action of the fire which decomposes one part of the sulphur produces the same effect. Thus, in the works at Schartzemberg in Upper Saxony, the vitriol is extracted, by lixiviating the pyrites after the distillation of the sulphur, which is called in some works, as we have before said, the *burnings of sulphur*, and which are in this work called *sulphur-brands*. This operation consists in impregnating well the lixivium with vitriol, by pouring it upon fresh parcels of these sulphur-brands, which is called doubling the lixivium: then it is evaporated in a leaden caldron, called the *sulphur-caldron*; and afterwards it is crystallized in a wooden vessel. The sulphur-brands, from which vitriol has been extracted, are not thereby exhausted; but they are exposed to the open air for two years, and are then again lixiviated for the extraction of more vitriol.

Vitriol is also made at *Geyer*, in Upper Saxony. The difference betwixt the method employed there and at Schwartzemberg, is, that at Geyer the pyrites has not been used for the extraction of sulphur by distillation, but has been roasted fifteen days, and afterwards lixiviated. The lixivium is evaporated in leaden caldrons, and afterwards put in shallow tubs called coolers, where it deposites a yellow mud. The evaporation and depuration of this lixivium last twenty-four hours, and then the liquor is put into tubs to crystallize.

The pyrites, which has been roasted and lixiviated once at Geyer, is not thereby exhausted; but is made to undergo the same operation four or five times, by which it furnishes more vitriol. The yellow mud which is deposited from the lixivium is sold, as a coloring material, to painters, after it has been calcined to redness.

Nature furnishes a vitriol ready formed in some mineral earths, to obtain which vitriol, nothing but lixiviation is necessary. Such is that vitriol obtained at

Cremnitz,

Cremnitz, where there is a rich ore of gold. The vitriol is there extracted merely for the purpose of preparing aqua fortis, which is necessary in the operation for parting the gold contained in that ore. In the neighbourhood of Cremnitz, a soft rock and clay are found, containing vitriol, and which furnish it by means of lixiviation.

To this kind of vitriol ready formed may be referred that obtained at Goslar by the lixiviation of a mineral earth, composed of particles of different ores, found in the galleries of the mine at Rammelsberg, of which we have already spoken. The workmen call this substance the *smoke of copper.* It requires lixiviation only to furnish vitriol. It is true, that by the wood-fires made in these galleries to calcine the rocks, the metallic matters may be disengaged, and a part of the sulphur burnt, the acid of which, mixing with the subterranean waters, dissolves all the metallic matters it meets, and forms all kinds of vitriols. Netherthelefs, some of these vitriolic waters, and even some crystallized vitriols, are found in these galleries, where no fire is ever made. The Germans call all these vitriols by the general name *Jockels.* Some vitriols are also found not crystallized, but forming various colored stones, which furnish vitriol by lixiviation. They are called *ink-stones.* What is called *misy* is a yellow, shining, vitriolic stone or earth, found in the same places.

To return to the substance called smoke of copper, whence the martial vitriol is extracted at Goslar, several lixiviums are made of it, by pouring the same water upon different parcels of it: it is then made to evaporate, to deposite its sediment, and to crystallize, as we have already said. The first water is called the *wild lie.* The several vessels employed at Goslar are named from their several uses, as the *washing tub, mud tub,* &c.

This substance remaining after the lixiviation of this smoke of copper, is a kind of ore not entirely deprived of metallic substances. The workmen call the finest part of it *small vitriol,* and the larger pieces they call *stones,* or *kernels of vitriol.* Both these are carried to the smelting-houses to be roasted and melted with the Rammelsberg ore, that the lead and silver, which they contain as well as that ore, may be extracted.

A white vitriol, whose basis is zinc, is also procured at Goslar from the same Rammelsberg ore. This vitriol was discovered in the year 1570 by the Duke Julian, who called it *alum of the mine.* At present it is known by the names, *white vitriol, vitriol of zinc, Goslar vitriol.*

To make this vitriol, the ore of Rammelsberg, containing lead and silver, having been previously roasted for the obtaining of sulphur, as we have already described, undergoes the same operations which are practised for the preparation of martial vitriol, excepting the formation of large crystals, which is here purposely prevented, by liquefying the vitriol after it is formed in copper caldrons. This liquefaction is effected by means of the water retained in the crystallization of the vitriol. While the vitriol is liquefied, a part of the moisture is evaporated, and women employed in this work keep stirring it till it has acquired the requisite consistence. By this stirring, it is divided into very fine crystalline particles, and it acquires the whiteness of the finest sugar; a quality which makes it saleable, and which is procured by the means above related, and by carefully making it deposite the ferruginous matter with which these lixiviums are always impregnated.

As to the blue vitriol, or vitriol of copper, it is extracted from the cupreous pyrites, or even from ſulphureous copper ores, by the operations already mentioned. Frequently the ferruginous pyrites and minerals alſo contain copper; and therefore the vitriol extracted from them is half martial and half cupreous, and is of a ſea-green color.

EXTRACTION *of* ALUM *from* PYRITOUS SUBSTANCES *and from* ALUMINOUS EARTHS.

One part of the unmetallic earth which is always in pyrites, and in other metallic and ſulphureous minerals, is ſometimes of that kind of earths which are ſoluble in acids, and particularly of the nature of that earth which is the baſis of alum.

When the pyrites contains ſome of this kind of earth, the acid of its ſulphur being diſengaged either by the efflorescence of the pyrites, or by its calcination and combuſtion, ought to unite itſelf as readily, and even more ſo, to this earth than to the metals contained in the ſame pyrites, and form a true alum: accordingly it ſo happens, and alum is extracted from pyrites or other ſulphureous minerals containing this earth, by proceſſes ſimilar to thoſe employed for the extraction of vitriols.

In England, a pyritous, ſlate-colored, ſulphureous ſtone is found, from which alum is extracted by torrefaction and lixiviation; but to this lixivium a certain quantity of foſſile alkali, diſſolved in water, is generally added.

The Swedes have a ſhining pyrites of a golden color, and ſpeckled with ſilvery ſpots, from which they extract ſulphur, vitriol, and alum. Sulphur and vitriol are extracted from it by the methods we have deſcribed; and when the lixivium yields no more cryſtals of vitriol, an eighth part of putrefied urine and lixivium of woodaſhes is added, by which a martial earth is precipitated: the liquor being poured off, cryſtals of alum are obtained by evaporation.

Finally, it appears that in general, when alum is to be extracted from ſulphureous and metallic minerals, fine and pure cryſtals cannot be without ſome difficulty obtained. It is almoſt always neceſſary to have recourſe to ſome additions of alkaline matters, ſuch as quicklime, and fixed or volatile alkaline ſalts.

Theſe difficulties proceed partly from this, that different kinds of ſalts are formed at the ſame time by the decompoſition of theſe minerals; and that theſe ſalts are cryſtallized by nearly the ſame degrees of evaporation and cold. Hence a confuſion of ſalts muſt neceſſarily follow: and hence we do not find many of the vitriols, extracted from ſuch minerals, perfectly pure and free from alum, or from vitriolic ſalts with earthy baſes ſimilar to alum. The *ſals of colcothar* and the *gilla vitrioli* are nothing elſe than theſe foreign ſalts. On the other hand, the alum which is extracted from metallic minerals contains almoſt always ſome vitriol, and particularly martial vitriol. (*k*)

(*k*) From Mr. Margraaf's experiments, an addition of ſome alkaline ſubſtance ſeems to be always neceſſary to the formation of large cryſtals of alum, however free the lixivium is from the mixture of vitriols, or other ſalts. See a note (*r*) ſubjoined to the article ALUM (ROCHE).

But there are unmetallic earths and ſtones which contain alum, or its materials, ready formed. Such is that earth whence alum is extracted at Solfatara. This mineral is an earth ſimilar to marle in conſiſtence and color. It is gathered in the plain, and in the weſtern part of the Solfatara. It is put into leaden caldrons two feet and a half in diameter, and as much in depth, till theſe veſſels be three quarters full. The caldrons are ſunk ſo as to be almoſt level with the ground, under a great hangar or ſhed, at a diſtance of four hundred paces from the ſulphur furnaces. Into each caldron water is poured till it riſe three or four inches above the mineral. The heat of the ground in this place is ſufficient to warm the matter, as it makes Mr. Reaumur's thermometer riſe to 37½ degrees above the freezing point. By this means, without the expence of wood, the ſaline part is ſeparated from the earthy, and is obtained in large cryſtals.

Alum in this ſtate is ſtill mixed with many impurities, and is carried to the building at the entry of the Solfatara, where it is diſſolved by hot water in a great ſtone veſſel in form of a funnel. The purification of alum may be made ſo much more advantageouſly in this place, as no wood is neceſſary, the natural heat of the place being ſufficient for the proceſs.

To this kind of natural alum may be referred that which is obtained merely by evaporation from ſome mineral waters; and alſo the Roman alum which is obtained from a kind of free-ſtone, although a calcination during twelve or fourteen hours, and an expoſition to the air till it falls into efflореſcence be neceſſary. This ſtone is not pyritous, but rather of the marle kind: therefore its efflorеſcence is probably nothing more than an extinction, and differs eſſentially from the efflorеſcence of pyrites.

Such are the proceſſes by which ſulphur, vitriol, and alum are obtained from minerals containing theſe ſubſtances.

Theſe minerals contain a great quantity of vitriolic acid, which chemiſts can ſeparate from them; and they are, as it were, the grand magazines where nature depoſites this acid, which is always found combined, as we have ſeen, with ſome ſubſtance or baſis.

SMELTING *of* ORES *in general.*

As ores conſiſt of metallic matters combined with ſulphur and arſenic, and are beſides intermixed with earthy and ſtony ſubſtances of all kinds, the intention of all the operations upon theſe compound bodies is to ſeparate theſe different ſubſtances from each other. This is effected by ſeveral operations founded on the known properties of thoſe ſubſtances. We now proceed to give a general idea of theſe ſeveral operations.

Firſt of all, the ore is to be ſeparated from the earths and ſtones accidentally adhering to it; and when theſe foreign ſubſtances are in large maſſes, and are not very intimately mixed in ſmall particles with the ore, this ſeparation may be accompliſhed by mechanical means. This ought always to be the firſt operation, unleſs the adherent ſubſtance be capable of ſerving as a flux to the ore. If the unmetallic earths be intimately mixed with the ore, this muſt neceſſarily be broken and divided into ſmall particles. This operation is performed by a

machine

machine which moves peſtles, called bocards, or ſtampers. After this operation, when the parts of the mineral are ſpecifically heavier than thoſe of the unmetallic earth or ſtone, theſe latter may be ſeparated from the ore by waſhing in canals through which water flows. With regard to this waſhing of ores, it is neceſſary to obſerve that it cannot ſucceed but when the ore is ſenſibly heavier than the foreign matters. But the contrary happens frequently, as well becauſe quartz and ſpar are naturally very ponderous, as becauſe the metallic matter is proportionably ſo much lighter as it is combined with more ſulphur.

When an ore happens to be of this kind, it is neceſſary to begin by roaſting it, in order to deprive it of the greateſt part of its ſulphur.

It happens frequently that the pyritous matters accompanying the ore are ſo hard that they can ſcarcely be pounded. In this caſe it is neceſſary to roaſt it entirely, or partly, and to throw it red-hot into cold water; by which the ſtones are ſplit, and rendered much more capable of being pulveriſed.

Thus it happens very frequently, that roaſting is the firſt operation to which an ore is expoſed.

When the ſubſtance of the ore is very fuſible, this firſt operation may be diſpenſed with, and the matter may be immediately fuſed without any previous roaſting, or at leaſt with a very ſlight one. For, to effect this fuſion, it is neceſſary that it retain a certain quantity of its ſulphur, which, with the other fluxes added, ſerves to deſtroy or convert into ſcoria a conſiderable part of the ſtoney matter of the mineral, and to reduce the reſt into a brittle ſubſtance which is called the *matt of lead*, or of *copper*, or other metal contained in the ore. This matt is therefore an intermediate matter betwixt the mineral and the metal; for the metal is there concentrated, and mixed with leſs uſeleſs matter than it was in the ore. But as this matt is always ſulphureous, the metal which it contains cannot have its metallic properties. Therefore it muſt be roaſted ſeveral times to evaporate the ſulphur, before it is remelted, when the pure metal is required. This fuſion of an ore not roaſted, or but ſlightly roaſted, is called *crude fuſion*.

We may here obſerve upon the ſubject of waſhing and roaſting of ores, that as arſenic is heavier than ſulphur, and has nearly the weight of metals, the ores in which it prevails are generally very heavy, and conſequently are ſuſceptible of being waſhed, which is a great advantage. But on the other ſide, as arſenic is capable of volatiliſing, ſcorifying, and deſtroying many metals, theſe ores have diſadvantages in the roaſting and fuſion, in both which conſiderable loſs is cauſed by the arſenic. Some ores contain, beſides arſenic, other volatile ſemi-metals, ſuch as antimony and zinc. Theſe are almoſt untractable, and are therefore neglected. They are called *minerae rapaces*, rapacious ores.

When the metal has been freed as much as is poſſible from foreign matters by theſe preliminary operations, it is to be completely purified by fuſions more or leſs frequently repeated; in which proper additions are made, either to abſorb the reſt of the ſulphur and arſenic, or to complete the vitrification or ſcorification of the unmetallic ſtones and earth.

Laſtly,

Laſtly, as ores frequently contain ſeveral different metals, theſe are to be ſeparated from each other by proceſſes ſuited to the properties of theſe metals, of which we ſhall ſpeak more particularly as we proceed in our examination of the ores of each metal. (*l*)

(*l*) To facilitate the extraction of metallic ſubſtances from the ores and minerals containing them, ſome operations previous to the fuſion or ſmelting of theſe ores and minerals are generally neceſſary. Theſe operations conſiſt of, 1. The *ſeparation* of the ores and metallic matters from the adhering unmetallic earths and ſtones, by hammers, and other mechanical inſtruments; and by waſhing with water. 2. Their *diviſion* or reduction into ſmaller parts by contuſion and trituration, that by another waſhing with water they may be more perfectly cleanſed from extraneous matters, and rendered fitter for the ſubſequent operations, calcination or roaſting, and fuſion. 3. *Roaſting* or *calcination*, the uſes of which operation are, to expel the volatile, uſeleſs, or noxious ſubſtances, as water, vitriolic acid, ſulphur, and arſenic; to render the ore more friable and fitter for the ſubſequent contuſion, and fuſion; and, laſtly, to calcine and deſtroy the viler metals; for inſtance, the iron of copper-ores, by means of the fire, and of the ſulphur and arſenic. Stones, as quartz, and flints, containing metallic veins or particles, are frequently made red hot, and then extinguiſhed in cold water, that they may be rendered ſufficiently friable and pulverable, to allow the ſeparation of the metallic particles.

Roaſting is unneceſſary for native metals; for ſome of the richer gold and ſilver-ores; for ſome lead-ores, the ſulphur of which may be ſeparated during the fuſion; and for moſt calciform ores, as theſe do not generally contain any ſulphur and arſenic.

In the roaſting of ores, the following attentions muſt be given. 1. To reduce the mineral previouſly into ſmall lumps, that the ſurface may be encreaſed; but they muſt not be ſo ſmall, nor placed ſo compactly, as to prevent the paſſage of the air and flame. 2. The larger pieces muſt be placed at the bottom of the pile, where the greateſt heat is. 3. The heat muſt be gradually applied, that the ſulphur may not be melted, which would greatly retard its expulſion; and that the ſpars, fluors, and ſtones, intermixed with the ores, may not crack, fly and be diſperſed. 4. The ores not thoroughly roaſted by one operation muſt be expoſed to a ſecond. 5. The fire may be encreaſed towards the end, that the noxious matters more ſtrongly adhering may be expelled. 6. Fuel which yields much flame, as wood and foſſil coals free from ſulphur, is ſaid to be preferable to charcoal or coaks. Sometimes cold water is thrown on the calcined ore at the end of the operation, while the ore is yet hot, to render it more friable.

No general rule can be given concerning the duration or degree of the fire, theſe being very various according to the difference of the ores. A roaſting during a few hours or days is ſufficient for many ores; while ſome, ſuch as the ore of Rammelſberg, require that it ſhould be continued during ſeveral months.

Schlutter enumerates five methods of roaſting ores. 1. By conſtructing a pile of ores and fuel placed in alternate ſtrata, in the open air, without any furnace. *See* Plate II. *Fig.* 11. *and Fig.* 12. 2. By confining ſuch a pile within walls, but without a roof. 3. By placing the pile under a roof, without lateral walls. 4. By placing the pile in a furnace conſiſting of walls and a roof. 5. By roaſting the ore in a reverberatory furnace, in which it muſt be continually ſtirred with an iron-rod.

Several kinds of *fuſions of ores* may be diſtinguiſhed. 1. When a ſulphureous ore is mixed with much earthy matter, from which it cannot be eaſily ſeparated, by mechanical operations, it is frequently melted, in order to diſengage it from theſe earthy matters, and to concentrate its metallic contents. By this fuſion, ſome of the ſulphur is diſſipated, and the ore is reduced to a ſtate intermediate betwixt that of ore and of metal. It is then called a *matt* (*lapis ſulphureo-metallicus*), and is to be afterwards treated like a pure ore by the ſecond kind of fuſion, which is properly the *ſmelting*, or *extraction of the metal by fuſion*. 2. By this fuſion or ſmelting, the metal is extracted from the ore previouſly prepared by the above operations, if theſe be neceſſary. The ores of ſome very fuſible metals, as of biſmuth, may be ſmelted by applying

OPERATIONS *on* ORES *of* NATIVE GOLD *and* SILVER, *by* WASHING *and by* MERCURY.

Earths and sand are at first separated by washing with water, by which operation the greatest part of what is not gold, being lighter, is carried off. After this a second washing is made with mercury, which having the property of uniting with gold, seizes this metal, amalgamates with it, and separates it exactly from the earthy matters, with all which it can form no union.

applying a heat sufficient only to melt the metals, which are thereby separated from the adhering extraneous matters. This separation of metals by fusion, without the vitrification of extraneous matters, may be called *eliquation*. Generally, a compleat fusion of the ore and vitrification of the earthy matters are necessary for the perfect separation of the contained metals. By this method, metals are obtained from their ores, sometimes pure, and sometimes mixed with other metallic substances, from which they must be afterwards separated; as we shall see, when we treat of the extraction of particular metals. To procure this separation of metals from ores, these must be so thinly liquefied, that the small metallic particles may disengage themselves from the scoria; but it must not be so thin as to allow the metal to precipitate before it be perfectly disengaged from any adhering extraneous matter, or to pervade and destroy the containing vessels and furnaces. Some ores are sufficiently fusible; but others require certain additions called *fluxes*, to promote their fusion, and the vitrification of their unmetallic parts; and also to render the scoria sufficiently thin to allow the separation of the metallic particles.

Different fluxes are suitable to different ores, according to the quality of the ore, and of the matrix, or stone adherent to it.

The matrixes of two different ores of the same metal frequently serve as fluxes to each other; as, for instance, an argillaceous matrix with one that is calcareous; these two earths being disposed to vitrification when mixed, tho' each of them is singly unfusible. For this reason, two or more different ores to be smelted are frequently mixed together.

The ores also, of different metals require different fluxes. Thus calcareous earth is found to be best suited to iron-ores, and spars and scoria to fusible ores of copper.

The fluxes most frequently employed in the smelting of ores are, calcareous earth, fluors or vitreous spars, quartz and sand, fusible stones, as slates, basaltes, the several kinds of scoria, and pyrites.

Calcareous earth is used to facilitate the fusion of ores of iron, and of some of the poorer ores of copper, and, in general, of ores mixed with argillaceous earths, or with feltspar. This earth has been sometimes added with a view of separating the sulphur, to which it very readily unites: but by this union, the sulphur is detained, and a hepar is formed, which readily dissolves iron and other metals, and so firmly adheres to them, that they cannot be separated without more difficulty than they could from the original ore. This addition is therefore not to be made till the sulphur be previously well expelled.

Fluors or *fusible spars* facilitate the fusion of most metallic minerals, and also of calcareous, and argillaceous earths, of steatites, asbestus, and of some other unfusible stones, but not of siliceous earths without a mixture of calcareous earth.

Quartz is sometimes added in the fusion of ferruginous copper ores, the use of which is said chiefly to be, to enable the ore to receive a greater heat, and to give a more perfect vitrification to the ferruginous scoria.

The *fusible stones*, as *slates*, *basaltes*, are so tenacious and thick when fused, that they cannot be considered properly as fluxes, but as matters added to lessen the too great liquidity of some very fusible minerals.

The *scoria* obtained in the fusion of an ore is frequently useful to facilitate the fusion of an ore of the same metal, and sometimes even of ores of other metals.

Sulphur and pyrites greatly promote the fusibility of the scoria of metals, from the sulphur it contains. [illegible] difficulty

The mercury thus charged with gold is pressed through shamoy leather, and the gold is retained united with a part of the mercury, from which it may be easily disengaged by exposure to a proper degree of heat, which dissipates and evaporates the mercury, while the gold, being fixed, remains.

This is the foundation of all the operations by which gold is obtained from the rich mines of Peru belonging to the Spaniards. These operations consist in washings, triturations, and amalgams in the great by help of machines. We shall not enter into these details, because they rather belong to mechanics than to chemistry. They who are desirous to know them, may consult a work written by Alonzo Barba on this subject.

The ores of native silver are much rarer and less abundant than those of gold. But if any of this kind were found sufficiently rich, they might be treated with mercury exactly in the same manner as the ores of native gold. *(m)*

difficultly fusible copper-ores, to form the sulphureous compounds called *matts*, that the ores thus brought into fusion may be separated from the adhering earthy matters, and that the ferruginous matter contained in them may be destroyed, during the subsequent calcination and fusion, by means of the sulphur.

As in the ores called *calciform*, the metallic matter exists in a calcined state; and as calcination reduces the metals of mineralised ores (excepting the perfect metals) to that state also; therefore all calciform and calcined ores require the addition of some *inflammable substance*, to furnish them with the phlogiston necessary for their reduction to a metallic state. In great works, the charcoal or other fuel used to maintain the fire produces also this effect.

Metals are sometimes added in the fusion of ores of other more valuable metals, to absorb from these sulphur or arsenic. Thus iron is added to sulphurated, cupreous, and silver ores. Metals are also added in the fusion of ores of other more valuable metals, to unite with and collect the small particles of these dispersed through much earthy matter, and thus to assist their precipitation. With these intentions, lead is frequently added to ores and minerals containing gold, silver, or copper.

Ores of metals are also sometimes added to assist the precipitation of more valuable metals. Thus antimony is frequently added to assist the precipitation of gold intermixed with other metallic matters. See *purification of gold by antimony*. Thus far of smelting of ores in general.

(*m*) Gold is frequently contained in the ores of other metals, either in a native or mineralised state, and in sands, especially those which are black and ferruginous. *See* Ores *of* Gold.

If *gold be contained in ores of other metals*, these metals together with the gold may be first extracted by the ordinary processes for smelting these ores; and the gold may be then separated from the metallic mass thus obtained, by mixing and fusing this mass with a quantity of lead, and by the process of cupellation, described in the articles Essay *of the* Value *of* Silver, *and* Refining. Generally, the operations for obtaining gold from ores of imperfect metals are precisely the same as those for obtaining silver, to which therefore we refer. Most frequently a quantity of silver also is contained in these ores; and in this case the perfect metal obtained by cupellation is an allay of gold and silver, which must be afterwards separated by the processes called *parting*. *See* Parting.

Many trials have been made to procure the small quantity of gold contained in the *ferruginous sands*, at a moderate expence (*See* Ores *of* Gold); but as no work of this kind is now established, we may presume they have not been successful. The best essays of this kind have been made, according to Schlutter, in the following manner.

The sand is to be made red-hot, and extinguished in cold water four times, by which its color is changed from the original yellow, red, or black, to a reddish brown. It is observed to emit, during the first and second calcinations, an arsenical smell; and this smell may be produced again in the following calcinations by adding some inflammable matter. Let an ounce of the calcined sand be mixed with two ounces of granulated

SMELTING *of* ORES *of* SILVER.

As silver, even in its proper ores, is always allayed with some other metals from which it is intended to be separated, after that the silver ore has been well roasted, it must be mixed with a greater or less quantity of lead previous to its fusion.

Lead has the same effect in fusion of gold and silver as mercury has upon these metals by its natural fluidity; that is to say, it unites with them, and separates them from unmetallic matters, which, being lighter, rise always to the surface. But lead has the further advantage of procuring, by its own vitrification, that of all metallic substances, excepting gold and silver. Hence it follows, that when gold and silver are obtained by means of mercury, they still remain allayed with other metallic substances; whereas when they are obtained by fusion and scorification with lead, they are then pure, and are not allayed with any metals but with each other.

In proportion as the lead, which has been united to the gold and silver of the ore, is scorified by the action of the fire, and promotes the scorification of the other metallic matters, it separates the perfect metals, and carries with it all the others to the surface. There it meets the unmetallic substances, which it likewise vitrifies, and which it changes into a perfect scoria, fluid, and such as a scoria ought to be to admit all the perfect metal contained in it to precipitate.

When all heterogeneous matters have been thus disengaged by scorification with lead, the perfect metals, to which some lead still remains united, are to be further purified by the ordinary operation of the cupel.

The common rule for the fusion and scorification of silver ore with lead, is to add to the ore a quantity of lead so much greater as there is more matter to be scorified, and as these matters are more refractory and of more difficult fusion. Silver ores, or those treated as such, are often rendered refractory by ferruginous

granulated lead, and one ounce of black flux, and put into a Hessian crucible, with half an ounce of decrepitated sea-salt upon the surface of the mixture. The crucible is to be placed in a good blast furnace, and a strong fire is to be excited. The matter contained in the crucible is to be frequently stirred with an iron-rod, and the heat is to be continued till the scoria is thin and perfectly fused. When the crucible is broken, a regulus of lead will be found, containing the gold and silver of the sand. By this method Mr. Leberecht obtained, in eleven essays, from 840 to 844 grains of perfect metal from a quintal of sand. Of the perfect metal obtained, from a fourth to a third part was gold. Some parcels of sand have yielded more than a thousand grains, and some not more than 350 grains per quintal. Instead of the granulated lead, and the black flux, which is too expensive for great operations, some have added, to an ounce of the sand, two ounces of litharge and a little powder of charcoal, by which they have obtained the same quantity of perfect metal. The scoria in these essays has been always found to contain some perfect metal.

The Hungarian copper ores, from which gold and silver are profitably extracted, contain a less quantity of these perfect metals than many ferruginous sands. But they may be formed into a matt, by fusion with pyrites, of which treatment the sands are incapable. From this matt, the gold and silver, along with the copper of the ore, may be precipitated, and separated from the sulphur of the pyrites, by addition of iron, which being more disposed than the other metals to unite with sulphur, disengages these metals, and allows them to precipitate.

earths,

earths, pyritous matters, or cobalts, containing always a confiderable quantity of an earth which is unmetallic, very fubtle, and very refractory, and which renders a confiderable augmentation of the quantity of lead neceffary.

The quantity of lead which is commonly added to fufible filver-ores, that do not contain lead, is eight times the quantity of the ore. But when the ore is refractory, it is neceffary to add twelve times the quantity of lead, and even more; alfo glafs of lead, and fluxes, fuch as the white and black fluxes; to which, however borax and powder of charcoal are preferable, on account of the liver of fulphur formed by thefe alkaline fluxes.

It is neceffary to obferve, that faline fluxes are only ufed in fmall operations, on account of their dearnefs. To thefe are fubftituted, in the great operations, of which we now treat, fandiver, fufible fcoria, and other matters of little value.

The greateft part of the filver now employed in commerce is not obtained from the proper ores of filver, which are very fcarce, but from lead, and even copper-ores, which are more or lefs rich in filver. To give an idea of the manner of treating thefe kinds of ores, from which filver is extracted in the great works, we fhall briefly defcribe here, after Schlutter, the fmelting of the ore of Rammelfberg, which contains, as we have already faid, feveral different kinds of metals, but particularly lead and filver.

When this mineral has been difengaged from its fulphur as much as poffible, by three very long roaftings, it is melted in the Lower Hartz in Saxony, in a particular kind of furnace, called a furnace for fmelting upon a hollow or *caffe*. *See* PLATE II. *Fig.* 13. The mafonry of this furnace is compofed of large, thick flates, capable of fuftaining great heat, and cemented together by clay. The interior part of the furnace is three feet and a half long, and two feet broad at the back part, and one foot only in the front. Its height is nine feet eight inches. It has a foundation of mafonry in the ground; and, in this foundation channels are made for the evaporation of the moifture. Thefe channels are covered over with ftones called *covering ftones*. The hollow or caffe, which is made above thefe, is formed of bricks, upon which are placed, firft, a bed of clay; then a bed of fmall ore and fifted vitriols; and, laftly, a bed of charcoal-powder beat down, called *light brafque*. The anterior wall of the furnace is thinner than the others, and is called the *chemife*. The back wall, which is pierced to give paffage to the pipes of two large wooden bellows, is called the middle wall. When the furnace is thus prepared, charcoal is thrown into the hollow, or caffe; which being kindled, the fire is to be continued during three hours, before the matters to be fufed are added. Then thefe matters are thrown in, which are not the pure ore, but a mixture of feveral fubftances, all of which are fomewhat profitable. The quantity of thefe matters is fufficient for one day's work; that is for a fufion of eighteen hours; and it confifts of; 1. Twelve fchorbens or meafures of well roafted Rammelfberg ore; (the fchorben is a meafure whofe contents are two feet five inches long, one foot feven inches broad, and a little more than a foot deep: It is equal to 32 quintals of that country, Cologn weight, at 123 pounds each quintal). 2. Six meafures of fcoria produced by the fmelting of the ore of Upper Hartz, which is refractory, and what workmen call *cold*. 3. Two meafures of *knobben*, which is an impure fcoria containing fome lead and filver,

 which

which has been formerly thrown away as uſeleſs, and is now collected by women and children. Beſides theſe, other matters are added, containing lead and ſilver, as the teſts employed in refining, the droſs of lead, impure litharge, and any rubbiſh containing metal, which was left in the furnace after the foregoing fuſion. All theſe matters being mixed together are thrown into the furnace: And to each meaſure of this mixture a meaſure of charcoal is added. The fuſion is then begun by help of bellows; and as it proceeds, the lead falls through the light braſque or charcoal bed, into the hollow, or caſſe, where it is preſerved from burning under the powder of charcoal. The ſcoria, on the other hand, being lighter and leſs fluid, is ſkimmed off from time to time by means of laddles, that it may not prevent the reſt of the lead from falling down into the hollow. Thus, while the fuſion laſts, freſh matters and freſh charcoal are alternately added, till the whole quantity intended for one fuſion, or, as they call it, one *day*, be thrown in.

There are ſeveral eſſential things to be remarked in this operation, which is very well contrived. Firſt, the mixture of matters from which a little lead and ſilver is procured, which would otherwiſe be loſt; and which have alſo this advantage, that they retard the fuſion of the Rammelſberg ore, which, however well roaſted it has been, retains always enough of the ſulphur and iron of the pyrites mixed with it, to render it too fuſible or too fluid, ſo that without the addition of thoſe matters, nothing would be obtained but a matt. It is even neceſſary, notwithſtanding theſe additions, not to haſten the fuſion too much, but to give time for the ore to mix with the other matters, elſe it would melt and flow of itſelf before the reſt. Secondly, the fuſion of the ore through charcoal, which is practiſed in moſt ſmelting-houſes and for almoſt all ores, is an excellent method, the principal advantage of which is the ſaving of fuel. The action of the burning charcoal directed immediately upon the mineral, at the ſame time that it melts it more readily and more effectually, alſo ſupplies it with the phlogiſton neceſſary to bring it to a perfect ſtate.

We mentioned, when treating of vitriols obtained from the Rammelſberg ore after its firſt roaſting, that a *white vitriol* was alſo obtained, and prepared at *Goſlar*, whoſe baſis was *zinc*: which proves that this ore contains alſo a certain quantity of this ſemi-metal. As this ore is ſmelted in a country where the art is well underſtood of extracting every thing which a mineral contains, ſo in this fuſion *zinc* and *cadmia* are obtained in the following manner. When the furnace is prepared for the fuſion, it is neceſſary to cloſe it up in the fore-part, before the fuſion is begun.

"First of all, a gritt-ſtone is to be placed, ſupported at the height of three "inches. This ſtone is as long as the furnace is broad, and the height of it "is level with the hole where the bellows pipe enters. It is faſtened on each ſide "of the furnace, externally and internally, with clay. Upon this ſtone a kind "of receptacle, or, as it is called, the *ſeat of the zinc*, is made in the following "manner. A flat, ſlaty ſtone is choſen, likewiſe as long as the furnace is "broad, and eight inches in breadth. This is placed on the gritt-ſtone above-"mentioned, in ſuch a manner, that it inclines conſiderably towards the front "of the furnace, and that its bottom touches cloſely the gritt-ſtone. It is "faſtened with clay, which is alſo laid upon the ſeat of the zinc. Upon this ſeat, "which is to receive the zinc, two round pieces of charcoal are placed, and upon

"theſe

" these a ſtone, called the *zinc ſtone*, reſts, which is about a foot and a half " in length, and cloſes one part of the front of the furnace. This ſtone alſo " is faſtened on each of its ſides with clay. Clay is likewiſe put under the " ſtone betwixt the two pieces of charcoal, which hinder it from touch- " ing the ſeat of the zinc. The under part of this ſtone is but ſlightly luted, " that the workmen may make an opening for the zinc to flow out. Thus " is made the ſeat or receptacle of the zinc to detain this metallic ſubſtance, " which would otherwiſe fall into the hotteſt part of the fire, called by the " workmen the melting place, and would be there burnt: whereas it is " collected upon this receptacle during the fuſion, where it is ſheltered from " the action of the bellows, and conſequently from too great heat.

" When all the matter to be fuſed in one day is put into the furnace, the " blaſt of air is continued till that matter has ſunk down. When it is half way " down the furnace, they draw out the ſcoria, that more of the ore and other " matters may be expoſed to the greateſt heat. As ſoon as the ſcoria is cooled " and fixed a little, two ſhovel-fulls of ſmall wet ſcoria or ſand is thrown cloſe " to the furnace, and beat down with the ſhovel; then the workmen open " the ſeat or receptacle of zinc, and ſtrike upon the zinc-ſtone to make the " ſemi metal flow out. As ſoon as the pureſt part of it has flowed out, it " is ſprinkled with water and carried away. Then the workmen ſeparate entirely " the zinc-ſtone from the wall of the furnace, and they continue to give it little " ſtrokes, that the ſmall particles of zinc diſperſed among the charcoal may " fall down. This being done, the ſtone is removed, and the zinc is " ſeparated from the charcoal by an iron inſtrument, is cleaned, and remelted " along with the zinc that flowed out at firſt, and is caſt into round cakes. " The reaſon why the zinc is withdrawn before the bellows ceaſe to blow, is, " that if it was left till the charcoal on the ſeat or receptacle was conſumed, it " would be moſtly burnt, and little would be obtained. Thus after the zinc [illegible] fuſion is finiſhed by blowing the bellows till the end."

Thus the zinc is ſeparated from the ore of Rammelſberg, and is not confounded in the matte or caſſe with the lead and ſilver, becauſe being a volatile ſemi-metal, it cannot ſupport the activity of the fire without riſing into vapors, which are condenſed in the place leaſt hot, that is to ſay, upon the ſtones expreſly prepared for that purpoſe, and which being much thinner than the other walls of the furnace, are continually cooled by the external air.

It is alſo in this furnace, and after the fuſion of the Rammelſberg ore, that the *cadmia of zinc*, or the *cadmia of furnaces*, is obtained. This ore is compoſed of ſulphureous and ferruginous pyrites, of true lead ore containing ſilver, and a very hard and compact matter of a dark browniſh-grey color, which is probably a lapis calaminaris, or an ore of zinc. Theſe ſeveral matters of the Rammelſberg ore are not ſeparated from each other, either for the roaſting or for the fuſion. Thus there is zinc in all the parts of the roaſted ore, and much more of it would be obtained, if it was not ſo eaſily inflammable. All the zinc which is obtained is preſerved from burning by falling, while in fuſion, behind the chemiſe or forepart of the furnace, which is, as has been ſaid, a kind of ſchiſtus or ſlate, called by the workmen *ſteel ſtone*. But the part of this ſemi-metal which falls in the middle of the furnace, near the middle wall,

or towards the sides, being exposed to the greatest heat of the fire, is there burnt; and its smoke or flowers attaching itself on all sides to the walls of the furnace, undergo there a semi-fusion, which renders this matter so hard and so thick that it must be taken away after every fourth fusion, or, at most, after every sixth fusion. That which is found attached to the highest part of the furnace is the best and purest. The rest is altered by a mixture of a portion of lead which it has carried up with it, and which from its great weight and fixity has hindered the zinc from rising so high as it would have done alone. Therefore with this kind of impure cadmia ductile brass cannot be made.

Almost all the zinc we have, as well as the cadmia of the furnaces, is obtained from the Rammelsberg ore, by the process described, and consequently is not the produce of a pure ore of zinc, or lapis calaminaris, which is never fused for that purpose. Before Mr. Margraaf, although it was well known that this ore contained zinc, and that it was employed for the making of brass, a convenient process for extracting zinc from it was not known, because when treated by fusion with fluxes, like other ores, it does not yield any zinc; which proceeds partly from the refractory quality of the earth contained in the calamine, that cannot be fused without a very violent fire; and also from the volatility and combustibility of the zinc, which for this reason cannot be collected at the bottom of a crucible, as a regulus under a scoria, like most metals.

M Margraaf has remedied these inconveniences by distilling lapis calaminaris, mixed with charcoal, in a retort, to which is joined a receiver containing some water, and consequently in close vessels, where the zinc by the help of a very strong fire indeed, is sublimed in its metallic form without burning. He also by the same method reduced into zinc the *flowers of zinc*, or *pompholix*, *cadmia of the furnaces*, *tutty*, which is also a kind of cadmia; in a word, all matters capable of producing zinc by combination with phlogiston. But it is evident that such operations as these are rather fit to supply proofs for chemical theory, than to be put in practice for works in great (*n*). M. Margraaf has observed, that the zinc which he obtained by this process was less brittle than what is obtained from the fusion of ores; which may proceed from its greater purity, or from its better combination with phlogiston.

After this digression which we have now made concerning the operation in the great, by which zinc and cadmia are obtained, and which we could not insert elsewhere, because of the necessary relation it has with the smelting of the Rammelsberg ore, we proceed to the other operations of the same ore, that is to say, to the *finery*, by which the silver is separated from the lead, which are mixed together, forming what is called the *work*.

(*n*) Zinc is obtained not only in the method used at Goslar above-described, but is also extracted in great works from lapis calaminaris and calcined blend, by a distillation similar to that by which Mr. Margraaf has essayed ores of zinc. The first work of that kind was erected in Sweden by Mr. Von Swab, in the year 1738. The ore employed was a kind of blend; this ore, when calcined, powdered, and mixed with charcoal, was put into iron or stone retorts, and the zinc was obtained by distillation. In Bristol a work is established in which zinc is obtained by a distillation *by descent*. See a section and description of the furnace and apparatus employed. Plate II. *Fig.* 22. and *explanation*.

This

This operation differs from the fining of essay, or in small, principally in this circumstance, that in the latter method of fining, all the litharge is absorbed into the cupel, whereas in the former method the greatest part of this litharge is withdrawn.

The fining in great of the work of Rammelsberg is performed in a furnace called a *reverberatory furnace*. This furnace is so constructed that the flame of wood burning in a cavity called the fire-place, is determined by a current of air (which is introduced through the ash-hole, and which goes out at an opening on one side of that part of the furnace where the work that is the lead and silver are) to circulate above, and to give the convenient degree of heat, when the fire is properly managed. In this furnace a great cupel, called a *test*, is disposed. This test is made of the ashes of beech-wood, well lixiviated in the usual manner. In some foundaries different matters are added, as sand, spar, calcined gypsum, quicklime, clay. When the test is well prepared and dried, all the work is put at once upon the cold test, to the quantity of sixty-four quintals for one operation. Then the fire is lighted in the fire-place with faggots, but the fusion is not urged too fast; 1. That the test may have time to dry: 2. Because the work of the Rammelsberg ore is altered by the mixture of several metallic matters, which it is proper to separate from it, otherwise they would spoil the litharge and the lead procured from it. These metallic matters are, copper, iron, zinc, and matt. As these heterogeneous substances are hard and refractory, they do not melt so soon as the *work*, that is, as the lead and silver; and when the work is melted, they swim upon its surface like a skin, which is to be taken off. These impurities are called the *scum*, or the *first-waste*. What remains forms a second scum, which appears when the work is at its greatest degree of heat, but before the litharge begins to form itself. It is a scoria which is to be carefully taken off. It is called the *second waste*.

When the operation is at this point, it is continued by the help of bellows, the wind of which is directed, not upon the wood or fuel, but upon the very surface of the metal, by means of iron plates put for that purpose before the blast-hole, which are called *papillons*. This blast does not so much encrease the intensity of the fire, as it facilitates the combustion of the lead, and throws the litharge that is not imbibed by the test towards a channel, called the *litharge way*, through which it flows. The litharge becomes fixed out of the furnace: the matter which is found in the middle of the largest pieces, and which amounts to about a half or a third of the whole, is friable, and falls into powder like sand. This is put into barrels containing each five quintals of it, and is called saleable litharge, because it is sold in that state. The other part which remains solid is called *cold litharge*, and is again melted and reduced into lead. The fusion is called *cold fusion*, and the lead obtained from it, *cold lead*, which is good and saleable when the *work* has been well cleared from the heterogeneous matters mentioned above. The tests and cupels impregnated with litharge are added in the fusion of the ore, as we have already related.

When two thirds, or nearly that quantity, of the lead are converted into litharge, no more of it is formed. The silver then appears covered with a white

white skin, which the finers call *lightening*, and the metal, *lightened* or *fined silver.*

The silver obtained by this process of fining is not yet altogether pure. It still contains some lead, frequently to the quantity of four drams in each marc, or eight ounces. It is delivered to the workmen, who compleat its purification by the ordinary method. This last operation is the *refining*, and the workmen employed to do it are called *refiners.* A fining of sixty four quintals of *work*, yields from eight to ten marcs of fined silver, and from 35 to 40 quintals of litharge; that is, from 12 to 18 of saleable litharge, from 22 to 23 of cold litharge, from 20 to 22 quintals of impregnated test, and from six to seven quintals of lead-dross. The operation lasts from 16 to 18 hours. (*o*)

(*o*) Ores containing silver may be divided into four kinds; 1. *Pure*, or those which are not much compounded with other metals. 2. *Galenical*, in which the silver is mixed with much *galena* or ore of lead mineralised by sulphur. 3. *Pyritous*, in which the silver is mixed with the martial pyrites. 4. *Cupreous*; in which the silver is contained in copper-ores. To extract the silver from these several kinds of ores, different operations are necessary.

Native silver is separated from its adhering earths and stones by amalgamation with mercury, in the manner directed for the separation of gold; or by fusion with lead, from which it may be afterwards separated by cupellation.

Pure ores seldom require a previous calcination, but, when bruised and cleansed from extraneous matters, may be fused directly, and incorporated with a quantity of lead; unless they contain a large proportion of sulphur and arsenic; in which case a calcination may be useful. The lead employed must be in a calcined or vitrified state, which, being mixed with the ore, and gradually reduced by the phlogiston of the charcoal added to it, may be more effectually united with the silver of the ore, than if lead itself had been added, which would too quickly precipitate to the bottom of the containing vessel or furnace. The silver is to be afterwards separated from the lead by cupellation.

Galenical ores, especially those in which pyrites is intermixed, require a calcination, which ought to be performed in an oven, or reverberatory furnace. They are then to be fused together with some inflammable matter, as charcoal, by which the lead is revived, and, together with the silver, is precipitated.

Pyritous ores must be first melted, so as to form a matt. If the sulphur is not sufficient for this kind of fusion, more sulphurated pyrites may be added. This matt contains, besides silver and sulphur, also various metals, as lead, iron, and sometimes cobalt. The matt must be exposed to repeated calcinations till the sulphur is dissipated. By these calcinations most of the iron is destroyed. The calcined matt is to be fused with litharge, and the silver incorporated with from the other imperfect metals with which it may be mixed, it must afterwards be separated by cupellation. *See* REFINING.

The silver contained in *cupreous ores* may be obtained, either, 1. By separating it from the copper itself, after this has been extracted along with the silver, in the usual manner, from the ore; or, 2. By precipitating it immediately, from the other matters of the ore.

1. It may be separated from the copper by two methods. One of these is by adding lead, and scorifying the imperfect metals. By this method much of the copper would be destroyed, and it is therefore not to be used unless the quantity of silver relatively to the copper be considerable. Another method by which silver may be separated from copper is, by *eliquation*; that is, by mixing the mass of copper and silver with a quantity of lead, and applying such a heat as shall be just sufficient to make the lead eliquate from the copper, together with the silver, which being more strongly disposed to unite with the lead than with the copper, is thus incorporated with the former metal, and separated

SMELTING *of* ORES *of* COPPER.

The smelting in great of copper ores, and even of several ores of silver and lead, excepting that of Rammelsberg, is performed in furnaces not essentially different from that already described; but in this respect only, that the scoria and metal are not drawn out of the furnace, but flow spontaneously, as soon as they are melted, into *receiving basons*, where the metal is freed from the scoria. These furnaces are generally called *pierced furnaces*.

Instead of a light brasque, or bed of charcoal-powder, under which the metal lies hid, the bottom of these furnaces is covered with a bason composed of heavy brasque, which is a mixture of charcoal-powder and clay. In the front of the furnace, and at the bottom of the chemise, there is a hole, called the *eye*, through which the melted matter flows, and runs along a trench or furrow, called the *trace*, into one or more *receiving basons*, made of earth, scoria, sand, &c. There the metal is separated from the scoria, by making it flow from these basons into another lateral one. These furnaces are also called *crooked furnaces*.

Different names are given to them according to some difference in their construction. For instance, those which have two *eyes*, and two *traces*, through which the melted matter flows alternately into two basons, are called *spectacle-furnaces*. Their greater or less height gives occasion also to the distinction of *high furnaces*, and *middle furnaces*.

The high furnaces are of modern invention. They were first introduced at Mansfeldt in the year [illegible], and they are now used in almost all countries where ores are smelted, as in Saxony, Bohemia, Hungary, &c. Their chief advantage consists in simplifying and diminishing the labor. This advantage is effected by the great height of the furnace, which allows the ore to remain there a long time before it falls down into the hottest part of the fire, and is melted. Consequently, it suffers successively different degrees of heat, and, before it is melted, it undergoes a roasting which costs nothing; therefore the high furnaces

rated from the latter. *See the article* ELIQUATION.

2. Silver may also be extracted from these cupreous ores by *precipitation*. For this purpose, let the ores, previously bruised and cleansed, be formed into a matt, that the earthy [illegible] well separated. Let the matt [illegible] with a strong fire; and when [illegible] has been roasted, and the heat is [illegible], add to it some clean galena, [illegible] when the fire [illegible] the additions well [illegible] cast or old iron [illegible] the matt, [illegible] lead is to unite with sulphur, will separate and precipitate the latter metal, and along with it the silver or gold contained in the matt. This method was introduced by Scheffer, and is practised at Adelfors in Smoland. In this work the proportion of the several materials is, four quintals of matt, two quintals of black copper containing some lead with the perfect metal, one quintal of galena, one quintal of litharge, a fifth part of a quintal of granulated lead, and an equal quantity of cast iron.

The silver in this, and in all other instances where it is united with lead, is to be afterwards separated from the lead by cupellation; which process is described at the article ESSAY *of the* VALUE *of* SILVER, *and* REFINING.

are chiefly employed for crude fusions, and particularly for the slate copper-ore. These furnaces are above eighteen feet high. A too great height is attended with an inconvenience, besides the trouble of supplying it with ore and fuel, which is, that the charcoal is mostly consumed before it gets down where the greatest heat is required, and it then rendered incapable of maintaining a fire sufficiently intense.

All the furnaces which we have mentioned are supplied with large bellows, moved by the arbor of a wheel, which is turned round by a current of water.

The only kind of furnace for smelting ores where bellows are not employed, is what is called a *reverberatory furnace*. The Germans call it a *wind-furnace*. It is also distinguished by the name of *English furnace*, because the invention of it is attributed to an English physician of the name of *Wright*, who was well versed in chemistry; and because the use of it was first introduced in England about the end of the last century, where it is much employed, as well as in several other countries, as at Konigsberg, in Norway. *See* PLATE III. *fig.* 14 *and* 15.

The length of these furnaces is about eighteen feet, comprehending the masonry: their breadth is twelve feet, and their height nine feet and a half. The hearth is raised three feet above the level of the foundery: on one side is the fire-place, under which is an ash-hole hollowed in the earth: on the other side is a bason made, which is kept covered with fire when there is occasion: on the anterior side of this furnace there is a chimney, which receives the flame after it has passed over the mineral that is laid upon the hearth. This hearth, which is in the interior part of the furnace, is made of a clay capable of sustaining the fire. The advantage of this furnace is, that bellows are not necessary, and consequently it may be constructed where there is no current of water, and wherever the mine happens to be. This furnace has a hole in its front through which the scoria is drawn out; and a bason, as we have said, on one side, made with sand, in which are oblong spaces for the reception of the *matt*, and of the *black copper*, when they flow out of the furnace.

Copper is generally mineralized, not only by sulphur and arsenic, but also by semimetals and pyritous matters, and is frequently mixed with other metals. As this metal has great affinity with sulphur and arsenic, it is almost impossible to disengage it from them entirely by roasting: hence in the smelting in great, nothing is obtained by the first operation but a copper-matt, which contains all the principles of the ore, excepting the earthy and stony parts, particularly when the ore is [illegible]. The [illegible] matt must be again roasted and fused. The product of the [illegible] still tends to resemble copper, but is not malleable [illegible] almost all the minerals, particularly with [illegible] a black color, it is always called *black copper*, [illegible] ever its color happens really to be.

As, of all the imperfect metals, copper is most difficultly burnt [illegible], it is again roasted several times, in order to burn [illegible] stances mixed with it; and the [illegible] is then called [illegible] and refining of it [illegible] of these happened to be in the [illegible]

In order to avoid all these fusions, it has been proposed to treat in the humid way certain copper ores, particularly those which are very pyritous. This method consists in making blue vitriol from the ore, by roasting and lixiviating it, and in precipitating pure copper from this lixivium, which is called *cement-water*, by means of iron; but it is not much practised, because it has been observed, that all the copper contained in the ore was not procured by this means.

As expence is not much regarded in small assays and experiments, these fusions are much abridged and facilitated by adding at first saline and glassy fluxes; and then by refining the black copper with lead in the cupel, as gold and silver are done. In this method of refining it is to be most carefully observed, that the metal be fused as quickly as possible, and exposed to no more heat than is necessary, lest it be calcined.

When the black copper contains some iron, but not a great deal, the lead perfectly separates the iron from it, and makes it rise to the surface of the copper; but if the iron be in too large a proportion, it prevents the lead from uniting with the copper. These two phenomena depend on the same cause, which is, that lead and iron cannot unite.

Frequently copper ores contain also a quantity of silver sufficient to make its extraction by particular processes profitable. It was long before any process could be thought of for this purpose, which was not too expensive and troublesome; but at length it was accomplished by the excellent operation, called *eliquation*. *See the word* ELIQUATION.

The copper from which silver has been separated by eliquation must be refined after this operation, as it is generally black copper from which silver is extracted; but even if it had not been black copper which was employed for this operation, it would require to be refined on account of a little lead it always retains. It is accordingly carried to the refiners furnace, where the operation is performed by help of bellows, the blast of which is thrown upon the surface of the melted metal. As in this refining of copper the precise time when it becomes pure cannot be known, because scoria is always formed on its surface, it is necessary to use an *essay-iron*, the polished end of which being dipt in melted copper, shows that the metal is pure when the copper adhering to the iron falls off as soon as it is dipt in cold water.

When this mark of the purity of the copper has been observed, its surface [illegible], and as soon as it begins to [illegible] it must be sprinkled [illegible] in cold water. [illegible] of the copper which is [illegible] from the rest of [illegible] into cold water: [illegible] of copper, [illegible] reduced into [illegible] what is called *rosette copper*. [illegible]

[illegible]

[illegible] and [illegible] are [illegible] methods [illegible] more [illegible] copper.

We shall not enter into further details concerning the operations made in great upon the different minerals, that we may not exceed the bounds intended

2. The iron of these ores is destructible by the burning sulphur during the roasting or the fusion of the ores, while the copper is not injured. This fact appears from experiments mentioned by Scheffer and by Wallerius, and from the daily practice of smelting cupreous ores.

From these facts we learn, 1. That sulphur may be employed to separate and destroy iron mixed with copper; 2dly, that iron may be employed to separate the sulphur from copper, as is sometimes done in the essay of sulphurated copper-ores; and, 3dly, that by adjusting the proportion of the iron and sulphur to each other in the smelting of copper-ores, these two substances may be made to destroy each other, and to procure a separation of the copper; and this adjustment may be effected, by adding sulphur or sulphureous pyrites to the copper-ore, when the quantity of sulphur contained in this ore relatively to the iron is too small; or by adding iron when the sulphur predominates; or by roasting, by which the superfluous sulphur may be expelled, and no more left than is sufficient for the destruction of the iron contained in the ore. We shall apply these principles to the following cases.

1. When the quantity of sulphur and of iron in a copper-ore is small, and especially when the iron does not too much abound, a previous roasting will at once calcine the iron, and expell most of the sulphur; so that by one fusion the calcined iron may be scorified, and black copper may be obtained. If the sulphur has not been sufficiently expelled, a second roasting and fusion are requisite; for the whole quantity of sulphur ought not to be expelled during the first roasting; but as much ought to be left as is sufficient for the scorification of the calcined iron, otherwise this might, during the fusion, be again revived and united with the copper.

2. If, in a copper-ore, the quantity of iron be too great, relatively to the sulphur, some sulphurated pyrites, especially that kind which contains copper, ought to be added, that a matt may be obtained, and that the iron may be calcined and scorified.

3. When the quantity of sulphur and iron is very great, that is, when the ore is very pyritous and poor, it ought to be first formed into a matt, by which it is separated from the adherent earths and stones, and the bulk is diminished; then by repeated and alternate roastings and fusions, the copper may be obtained.

4. When the quantity of sulphur in an ore is greater than is sufficient for the forming a matt, the superfluous quantity ought to be previously expelled by roasting.

The copper thus at first obtained is never pure, but is generally mixed with sulphur or with iron. It is called *black copper*. This may be refined in furnaces, or on hearths.

In the former method, to the copper when melted a small quantity of lead is added, which unites with the sulphur, and is scorified together with the iron, and floats upon the surface of the melted copper. This purification of copper by means of lead is similar to the refining of silver by cupellation, and is founded on the property of lead, by which it is more disposed to unite with sulphur than copper is, and on a property of copper, by which it is less liable than any other imperfect metal to be scorified by lead. But as copper is also capable of being scorified by lead, this operation must be no longer continued, and no more lead must be employed than is sufficient for the separation of the sulphur, and for the scorification of the iron.

The copper might also be purified from any remaining sulphur by adding a sufficient quantity of iron to engage the sulphur. Thus Mr. Scheffer found, that by adding to sulphurated copper from 8th to [illegible] of old cast iron, he rendered the cop[illegible] ductile. *See his Dissertation in* [illegible] *Academy* [illegible] *year 1752*. In [illegible] quantity of iron added ought not to be too little, else all the sulphur will not be separated; and it ought not to be too great, else the superfluous quantity will unite with and injure the [illegible] of the copper. The fusion and scorification, with addition of lead, seems to be the best method for the last purification of copper.

for this work. Besides, what remains to be said upon the ores of mercury, antimony, bismuth, arsenic, and cobalt, is already sufficiently explained in the different articles of this Dictionary relating to these substances, and to their products. The fusion in great of ores of iron would indeed particularly deserve to be treated more extensively, on account of its importance; but we observe, that the general principles of the smelting of ores contained in the present article are as applicable to ores of iron as of other metals, and for the particular details we are obliged to refer to good Treatises, which are not wanting on this subject, and particularly to the *Art of Forges and Iron-furnaces*, described most exactly by the Marquis de Courtivron, of the Royal Academy of Sciences, and by M. Bouchu, a correspondent of that Academy; a work which makes part of a general description of the Arts undertaken by that illustrious company. (*q*)

(*q*) In this work, which pretends to treat of the principles of arts in general, we ought certainly not to omit some description of the methods of procuring and manufacturing a metal, so extensively useful, that without it no other art could have been perfected, and even, as some writers have observed, mankind could not have been civilized.

In the article Iron, the author of the Dictionary has described the chemical properties of that metal, or its effects when acted upon by fire, acids, and other substances. The subjects of this note and of the article Steel are the processes by which iron is obtained from its ores, and reduced to the several states of *cast iron*, *forged iron*, and *steel*, and the properties of this metal in these several states, which render it fit for the various uses to which it is daily applied.

Notwithstanding the great importance of these subjects, and the labors of Reaumur, Swedenborgius, and of some other authors, we have still a very imperfect knowledge of the causes of the differences of the several kinds of ores, of the methods of smelting best adapted to these differences, of the causes of the good and bad qualities of different kinds of iron, and of the means of so meliorating this metal, that we may obtain tough and ductile iron from any of its ores.

Swedenborgius has very industriously and exactly described the different processes now used in most parts of Europe for the smelting of ores of iron, for the forging of that metal, and for the conversion of it into steel: but we do not find that he or any other author has, by experiments and discoveries, contributed much to the illustration or to the improvement of this part of metallurgy, unless, perhaps, we except those of Mr. Reaumur, concerning the softening of cast iron by cementation with earthy substances.

The *ores of iron* are known to vary much in their appearance, in their contents, in their degrees of fusibility, in the methods necessary for the extraction of their contained metal, and in the qualities of the metal when extracted.

Most ores require to be *roasted* previously to their fusion; some more slightly, and others with a more violent and longer-continued fire. Those which contain much sulphur, arsenic, or vitriolic acid, require a long-continued and repeated roasting, that the volatile matters may be expelled.

Some ores require a very slight roasting only, that they may be dried and rendered friable. Such are the ores called *bog ores*, and others, which being in a calcined state, and containing no sulphureous or inflammable matter, would, by a further calcination, be rendered less capable of uniting with phlogiston, and consequently of being reduced to a metallic state.

Also the ores which are attractable by magnets, and which contain iron in a state nearly metallised, require little or no roasting.

The roasting of ores of iron is performed by kindling piles, consisting of strata of fuel and of ore, placed alternately upon one another, (*See* Plate II. *Fig.* 11. *and* 12.), or in furnaces similar to those commonly employed for the calcination of lime-stone.

Some authors advise the addition of some calcareous earth to sulphureous ores during the roasting, that the sulphur may be absorbed

DCXXXII. SNOW *of* ANTIMONY. The flowers of regulus of antimony are fo called. *See* FLOWERS *of* REGULUS *of* ANTIMONY.

forbed by this earth when converted into quicklime. But we may obferve, that the quicklime cannot abforb the fulphur or fulphureous acid, till thefe be firft extricated from the ore, and does therefore only prevent the diffipation of thefe volatile matters; and, fecondly, that the fulphur thus united with the quicklime forms a hepar of fulphur, which will unite with and diffolve the ore during its fufion, and prevent the precipitation of the metal.

The next operation is the *fufion* or *fmelting* of the ore. This is generally performed in furnaces or towers, from twenty to thirty feet high, in the bottom of which is a bafon for the reception of the fluid metal. *See a Section and Defcription of this Furnace in* PLATE II. *Fig.* 20, *and the Explanation of that Figure.* When the furnace is fufficiently heated, which muft be done at firft very gradually, to prevent the cracking of the walls; a quantity of the ore is to be thrown in, from time to time, at the top of the furnace, along with a certain quantity of fuel and of limeftone, or whatever other flux is employed. While the fuel below is confumed by the fire excited by the wind of the bellows, the ore, together with its proportionable quantity of fuel and of flux, fink gradually down, till they are expofed to the greateft heat in the furnace. There the ore and the flux are fufed, the metallic particles are revived by the phlogifton of the fuel, are precipitated by means of their weight through the fcoria formed of the lighter earthy parts of the flux and of the ore, and unite in the bafon at the bottom of the furnace, forming a mafs of fluid metal covered by a glaffy fcoria. When a fufficient quantity of this fluid metal is collected, which is generally twice or thrice in twenty-four hours, an aperture is made, through which the metal flows into a channel or groove made in a bed of fand; and from thence into fmaller lateral or contiguous channels, or other moulds. There it is cooled, becomes folid, and retains the forms of the channels or moulds into which it flows. The piece of iron formed in the large channel is called *a fow*, and thofe formed in the fmaller channels are called *pigs*. Sometimes the fluid iron is taken out of the furnace by means of ladles, and poured into moulds, ready prepared, of fand or of clay, and is thus formed into the various utenfils and inftruments for which caft iron is a proper material.

The *fcoria* muft be, from time to time, allowed to flow out, when a confiderable quantity of it is formed, through an aperture made in the front of the furnace for that purpofe. A fufficient quantity of it muft, however, be always left to cover the furface of the melted iron; elfe the ore which would fall upon it, before the feparation of its metallic from its unmetallic parts, would leffen the fluidity and injure the purity of the melted metal. This fcoria ought to have a certain degree of fluidity; for if it be too thick, the revived metallic particles will not be able to overcome its tenacity, and collect together into drops, nor be precipitated. Accordingly, a fcoria not fufficiently fluid, is always found to contain much metal. If the fcoria be too thin, the metallic particles of the ore will be precipitated before they are fufficiently metallized, and feparated from the earthy and unmetallic parts. A due degree of fluidity is given to the fcoria by applying a proper heat, and by adding fluxes fuited to the ore.

Some ores are fufible without addition, and others cannot be fmelted without the addition of fubftances capable of facilitating their fufion.

The *fufible ores* are thofe which contain fulphur, arfenic, or are mixed with fome fufible earth.

The *ores difficultly fufible* are thofe which contain no mixture of other fubftance. Such are moft of the ores which are attractable by magnets, and which contain iron in a ftate nearly metallic. As iron itfelf, when purified from all heterogeneous matters, is fcarcely fufible without addition, fo the metal contained in thefe pure kinds of ores cannot be eafily extracted without the addition of fome fufible fubftance. [illegible] which are mixed with fome very refractory fubftance. Some of thefe refractory ores contain arfenic; but as this fubftance facilitates the fufion of iron, we may prefume that

DCXXXIII. SOAP. The name *ſoap* was formerly employed only to ſignify combinations of alkaline ſalts with oils, that is, compounds in which

that their refractory quality depends upon a mixture of ſome unmetallic earth or other unfuſible ſubſtance.

Perhaps the fuſibility of different ores depends greatly on the degree of calcination to which the metal contained in them has been reduced; ſince we have reaſon to believe that, by a very perfect calcination, ſome metals, at leaſt, may be reduced to the ſtate of an earth almoſt unfuſible, and incapable of that intimate union with phlogiſton in which metalliſation conſiſts (*ſee the article* METALS); and ſince we know, that in every calcination and ſubſequent reduction of a given quantity of any imperfect metal, a ſenſible part of that quantity is always loſt or deſtroyed, however carefully theſe operations may have been performed. If this notion be juſt, the moſt probable means of improvement in the ſmelting of ores of imperfect metals, eſpecially of iron, ſeem to be by diſcovering ſome method of effecting the combination or intimate union of phlogiſton with metallic earths or calxes, more compleatly and certainly than by immediately expoſing them to a melting heat, in which thoſe metallic particles only can be revived, that are already much diſpoſed to metalliſation. That ſome of theſe ores are already too much calcined, appears from the inſtance above-mentioned of the *bog ores*, which are injured by roaſting; and even the great height of the common ſmelting furnaces, although advantageous to many ores that require much roaſting, is ſaid to be injurious to thoſe which are already too much calcined, by expoſing them to a further calcination, during their very gradual deſcent, before they arrive at the hotteſt part of the furnace, where they are fuſed.

Further, when we conſider how many inſtances occur of combinations which can be effected only by ſlow degrees, we have reaſon to hope, that methods of more effectually combining phlogiſton with metallic earths may be diſcovered, by which a larger proportion of metal may be obtained from the ores, eſpecially the calciform ores of iron, and perhaps of other imperfect metals, than is now obtained by the methods commonly practiſed.

Various ſubſtances are added to aſſiſt the fuſion of ores difficultly fuſible. Theſe are; 1. *Ores* of a fuſible quality, or which, being mixed with others of a different quality, become fuſible: accordingly, in the great works for ſmelting ores of iron, two or more different kinds of ore are commonly mixed, to facilitate the fuſion, and alſo to meliorate the quality of the iron. Thus an ore yielding an iron which is brittle when hot, which quality is called *red-ſhort*, and another ore which produces iron brittle when cold, or *cold-ſhort*, are often mixed together; not, as is ſometimes ſuppoſed, that theſe qualities are mutually deſtructive of each other, but that each of them is diminiſhed in the mixed maſs of iron, as much as this maſs is larger than the part of the maſs originally poſſeſſed of that quality. Thus, if from two ſuch ores the maſs of iron obtained conſiſts of equal parts of cold-ſhort and of red-ſhort iron, it will have both theſe qualities, but will be only half as *cold-ſhort* as iron obtained ſolely from one of the ores, and half as *red-ſhort* as iron obtained only from the other ore. 2. *Earths* and *ſtones* are alſo generally added to facilitate the fuſion of iron ores. Theſe are ſuch as are fuſible, or become fuſible when mixed with the ore, or with the earth adhering to it. Authors direct that, if this earth be of an argillaceous nature, limeſtone or ſome calcareous earth ſhould be added; and that if the adherent earth be calcareous, an argillaceous earth ſhould be added; becauſe theſe two earths, though ſingly unfuſible, yet, when mixed, mutually promote the fuſion of each other; but as limeſtone is almoſt always added in the ſmelting of iron-ores, and as in ſome of theſe, at leaſt, no argillaceous earth appears to be contained, I am inclined to believe, that it generally facilitates the fuſion, not by uniting with an argillaceous earth, but by uniting with that part of the ore which is moſt perfectly calcined, and leaſt diſpoſed to metalliſation; ſince we know, that by mixing a calciform or roaſted ore of iron with calcareous earth, without any inflammable matter, theſe two ſubſtances may be totally vitrified. *See Experiments made upon Quicklime, and upon Iron,*

by

oils are rendered miscible with water, by means of an alkali. But since chemists, by a more exact examination of the nature of bodies, have dis-

by Mr. Brandt, in the Swedish Memoirs for the years 1749 *and* 1751.

Some authors pretend, that a principal use of the addition of lime-stone in the smelting of iron-ores is to absorb the sulphur, or vitriolic acid, of these ores: but, as we have already observed, a hepar of sulphur is formed by that mixture of calcareous earth and sulphur, which is capable of dissolving iron in a metallic state; and thus the quantity of metal obtained from an ore not sufficiently divested of its sulphur, or vitriolic acid, (which, by uniting with the phlogiston of the fuel, is formed into a sulphur during the smelting) must be considerably diminished, though rendered purer, by addition of calcareous earth: hence the utility appears of previously expelling the sulphur and vitriolic acid from the ore by a sufficient roasting. 3. The *scoria* of former smeltings is frequently added to assist the fusion of the ore; and, when the scoria contains much iron, as sometimes happens in ill conducted operations, it also encreases the quantity of metal obtained.

The quantity of these fusible matters to be added varies according to the nature of the ore; but ought in general to be such, that the scoria shall have its requisite degree of thinness, as is mentioned above.

The *fuel* used in most parts of Europe for the smelting of ores of iron is charcoal. Lately, in several works in England and Scotland, iron-ore has been smelted by means of pitcoal, previously reduced to cinders or *coaks*, by a kind of calcination similar to the operation for converting wood into charcoal, by which the aqueous and sulphureous parts of the coal are expelled, while only the more fixed bituminous parts are left behind. In France, pitcoal not calcined has been tried for this purpose, but unsuccessfully. The use of *peat* has also been introduced in some parts of England.

The quality of the iron depends considerably upon the quality and also upon the quantity of the fuel employed. Charcoal is fitter than coaks for producing an iron capable of being rendered malleable by forging.

The quantity of fuel, or the intensity of the heat, must be suited to the greater or less fusibility of the ore. Sulphureous, and other ores easily fusible, require less fuel than ores difficultly fusible. In general, if the *quantity of fuel be too small*, and the heat not sufficiently intense, all the iron will not be reduced, and much of it will remain in the scoria, which will not be sufficiently thin. This defect of fuel may be known by the blackness and compactness of the scoria, by the qualities of the iron obtained, which in this case is hard, white, light, intermixed with scoria, smooth in its texture, without scales or grains, rough and convex in its surface, and liable to great loss of weight by being forged; and, lastly, it may be known by observing the color and appearance of the drops of metal falling down from the smelted ore, and of the scoria upon the surface of the fluid metal, both which are darker-colored than when more fuel is used. When the *quantity of fuel is sufficiently large*, and the heat is intense enough, the iron is darker-colored, denser, more tenacious, contains less scoria, and is therefore less fusible, and loses less of its weight by being forged. Its surface is also smoother and somewhat concave; and its texture is generally granulated. The scoria, in this case, is of a lighter color and less dense. The drops falling from the smelted ore and the liquid scoria in the furnace appear hotter and of a brighter color. When the quantity of fuel is too great, and the heat too intense, the iron will appear to have a still darker color, and more conspicuous grains or plates, and the scoria will be lighter, whiter, and more spungy. The drops falling from the smelted ore, and the fluid scoria, will appear to a person looking into the furnace through the blast-hole to be very white and shining hot. The quantity of charcoal necessary to produce five hundred weight of iron, when the ore is rich, the furnace well contrived, and the operation skilfully conducted, is computed to be about forty cubic feet; but is much more in contrary circumstances.

The *time, during which the fluid metal ought to be kept in fusion* before it is allowed to flow out of the

covered, that acids, and even other saline substances, may also be united with oils, and may render these miscible with water, they have generalised the name

the furnace must be also attended to. How long that time is, and whether it ought not to vary according to the qualities of ores and other circumstances, we cannot determine. In some works the metal is allowed to flow out of the furnace every six or eight, and in others only every ten or twelve hours. Some workmen imagine, that a considerable time is necessary for the concoction of the metal. This we are certain of, that the iron undergoes some change by being kept in a fluid state; and that if its fusion be prolonged much beyond the usual time, it is rendered less fluid, and also its cohesion, when it becomes cold, is thereby greatly diminished. The Marquis de Courtivron says, that the cohesion may be restored to iron in this state, by adding to it some vitrescible earth, which he considers as one of the constituent parts of iron, and which he thinks is destroyed by the fusion too long continued. That the fusibility of cast iron does depend on an admixture of some vitrescible earth, appears probable from the great quantity of scoria forced out of iron during its conversion into malleable or forged iron, and from the loss of fusibility which it suffers nearly in proportion to its loss of scoria. The quantity of iron daily obtained from such a furnace as we have described, is from two to five tons in twenty-four hours, according to the richness and fusibility of the ore, to the construction of the furnace, to the adjustment of the due quantity of flux and of fuel, and to the skill employed in conducting the operation.

The *quality of the iron* is judged by observing the appearances during its flowing from the furnace, and when it is fixed and cold. If the fluid iron, while it flows, emits many and large sparkles; if many brown spots appear on it while it is yet red-hot; if when it is fixed and cold, its corners and edges are thick and rough, and its surface is spotted; it is known to have a red-short quality. If, in flowing, the iron seems covered with a thin glassy crust, and if, when cold, its texture be whitish, it is believed to be cold-short. Mr. Reaumur says, that dark-colored cast iron is more impure than that which is white. The Marquis de Courtivron is of a contrary opinion. But no certain rules for judging of the quality of iron before it be forged can be given. From brittle cast iron, sometimes ductile forged iron is produced. Cast iron with brilliant plates and points, when forged, becomes sometimes red short and sometimes cold-short. Large shining plates, large cavities called *eyes*, want of sufficient density, are almost certain marks of bad iron; but whether it will be cold or red-short cannot be affirmed till it be forged. Whiteness of color, brittleness, closeness of texture, and hardness, are given to almost any cast iron by sudden cooling; and we may observe, that in general the whiter the metal is, the harder it is also, whether these properties proceed from the quality of the iron, or from sudden cooling; and that, therefore, the darker-colored iron is fitter for being cast into moulds, because it is capable in some measure of being filed and polished, especially after it has been exposed during several hours to a red-heat in a reverberatory furnace, and very gradually cooled. This operation, called by workmen *annealing*, changes the texture of the metal, renders it softer, and more capable of being filed than before, and also considerably less brittle.

Mr. Reaumur found, that by cementing cast iron with absorbent earths in a red-heat, the metal may be rendered softer, tougher, and consequently a fit material for many utensils formerly made of forged iron. Whether cementation with absorbent earths gives to cast iron a greater degree of these properties than the annealing commonly practised, has not been yet determined.

In Navarre, and in some of the southern parts of France, iron-ore is smelted in furnaces much smaller, and of a very different construction from those above described. A furnace of this kind consists of a wide-mouthed copper-caldron, the inner surface of which is lined with masonry a foot thick. The mouth of the caldron is nearly of an oval or elliptic form. The space or cavity contained by the masonry is the furnace in which the ore is smelted. The depth of this cavity is equal to two feet and a half: the larger diameter of the oval mouth of the

 cavity

name of ſoap, and the beſt chemiſts give it now to all combinations of any ſaline ſubſtances with oils, rendered miſcible with water by means of theſe ſaline

cavity is about eight feet, and its ſmaller diameter is about ſix feet: the ſpace of the furnace is gradually contracted towards the bottom, the greateſt diameter of which does not exceed ſix feet: eighteen inches above the bottom is a cylindrical channel in one of of the longer ſides of the caldron and maſonry, through which the nozzle of the bellows paſſes. This channel, and alſo the bellows-pipe, are ſo inclined, that the wind is directed towards the loweſt point of the oppoſite ſide of the furnace. Another cylindrical channel is in one of the ſhorter ſides of the furnace, at the height of a few inches from the bottom, which is generally kept cloſed, and is opened occaſionally to give paſſage to the ſcoria; and above this is a third channel in the ſame ſide of the furnace, through which an iron inſtrument is occaſionally introduced to ſtir the fluid metal, and to aſſiſt, as is ſaid, the ſeparation of the ſcoria from it. The greateſt height of this channel is at its external aperture on the outſide of the furnace, and its ſmaller height is at its internal aperture; ſo that the inſtrument may be directed towards the bottom of the furnace; but the ſecond channel below it has a contrary inclination, that when an opening is made, the ſcoria may flow out of the furnace into a baſon placed for its reception. When the furnace is heated ſufficiently, the workmen begin to throw into it alternate charges of charcoal, and of ore previouſly roaſted. They take care to throw the charcoal chiefly on that ſide at which the wind enters, and the ore at the oppoſite ſide. At the end of about four hours a maſs of iron is collected at the bottom of the furnace, which is generally about ſix hundred weight: the bellows are then ſtopt; and when the maſs of iron is become ſolid, the workmen raiſe it from the bottom of the furnace, and place it, while yet hot, under a large hammer, where it is forged. The iron produced in theſe furnaces is of the beſt quality: the quantity is alſo very conſiderable, in proportion to the quantity of ore, and to the quantity of fuel employed. In theſe furnaces no limeſtone or other ſubſtance is uſed to facilitate the fuſion of the ore. We ſhould receive much inſtruction concerning the ſmelting of iron-ore, if we knew upon what part of the proceſs or circumſtance, the excellence of the iron obtained in theſe furnaces depends; whether on the quality of the ore; on the diſuſe of any kind of flux, by which the proportion of vitreous or earthy matter, intermixed with the metallic particles, is diminiſhed; on the forging while the iron is yet ſoft and hot, as the Marquis de Courtivron thinks; or on ſome other cauſe, not obſerved.

The iron thus produced by ſmelting ores is very far from being a pure metal; and though its fuſibility renders it very uſeful for the formation of cannon, pots, and a great variety of utenſils, yet it wants the ſtrength, toughneſs, and malleability, which it is capable of receiving by further operations.

Caſt-iron ſeems to contain a large quantity of vitreous or earthy matter mixed with the pure iron; which matter is probably the chief cauſe of its fuſibility, brittleneſs, hardneſs, and other properties by which it differs from forged iron. The ſulphur, arſenic, and other impurities of the ores, which are ſometimes contained in caſt iron, are probably only accidental, and may be the cauſes of the red-ſhort quality, and of other properties of certain kinds of iron: but the earthy matter above-mentioned ſeems principally to diſtinguiſh caſt iron from forged or malleable iron; for, firſt, by depriving the former of this earthy matter, it is rendered malleable, as in the common proceſs hereafter to be deſcribed; and, ſecondly, by fuſing malleable iron with earthy and vitreſcible matters, it loſes its malleability, and is reſtored to the ſtate and properties of caſt iron.

The earthy vitreous matter contained in caſt iron conſiſts probably of ſome of the ferruginous earth or calx of the ore not ſufficiently metalliſed, and alſo of ſome unmetallic earth. Perhaps it is only a part of the ſcoria which adheres to, and is precipitated with, the metallic particles, from which it is more and more ſeparated, as the heat applied is more intenſe, and as the fuſion is longer continued.

To ſeparate theſe impurities from caſt iron, and to unite the metallic parts more cloſely

ſubſtances. The vegetable kingdom contains many ſuch ſaline, oily combinations ſoluble in water. All vegetable acids, fluor or concrete; eſſential ſalts; ſac-

cloſely and compactly, and thus to give it the ductility and tenacity which render this metal more uſeful than any other, are the effects produced by the following operations.

The firſt of theſe operations is a fuſion of the iron, by which much of its impurities is ſeparated in form of ſcoria; and by the ſecond operation, a further and more compleat ſeparation of theſe impurities, and alſo a cloſer compaction of the metallic particles, are effected by the application of mechanical force or preſſure, by means of large hammers.

Some differences in the conſtruction of the forge or furnace, in which the *fuſion* or *refining of caſt iron* is performed, in the method of conducting the operation, and in ſome other circumſtances, are obſerved to occur in different places. We ſhall deſcribe, from Suedenborgius, the *German method*.

The fuſion of the caſt-iron, which is to be rendered malleable, is performed upon the hearth of a forge ſimilar to that uſed by blackſmiths: at one ſide of this hearth is formed a cavity or fire place, which is intended to contain the fuel and the iron to be melted: this fireplace is twenty inches long, eighteen inches broad, and twelve or fourteen inches deep: it is bounded on three ſides by three plates of caſt-iron placed upright; and on the fourth ſide, which is the front, or that part neareſt to which the workmen ſtand, by a large forge-hammer, through the eye of which the ſcoria is at certain times allowed to flow. The floor alſo of the fire-place is another caſt-iron plate. The thickneſs of theſe plates is from two to four inches. One of the upright ſide-plates reſts againſt a wall, in an aperture thro' which a copper tube, called the *tuyere*, is luted with clay. This tube is a kind of caſe or covering for the pipe of a pair of bellows placed behind the wall, and its direction is therefore parallel to that of the bellows-pipe; but it advances about half a foot further than this pipe into the fire-place; and thus gives greater force to the air, which it keeps concentrated, or prevents the divergency of the air, till it is required to act. The tube reſts upon the upper edge of the ſide-plate which leans againſt the wall, nearer to the back-part than to the front of the fire-place, and in ſuch an oblique direction, that the wind ſhall be impelled towards the furtheſt part of the floor of the fire-place, or where this floor is interſected by the oppoſite ſide plate. The obliquity of the tuyere ought to vary according to the quality of the iron: and therefore, in every operation, it may be ſhifted till its proper poſition is found. The more nearly its direction approaches to a horizontal plane, the more intenſe is the heat; but a larger quantity of fuel is conſumed than is even proportional to the encreaſe of heat, becauſe the flame is not then ſo well confined. When the iron is eaſily fuſible, great heat is not required: the tuyere may then decline conſiderably from the horizontal plane, and thus fuel may be ſaved. This tuyere, though made of copper, a metal more eaſily fuſible than iron, is preſerved from fuſion by the conſtant paſſage of cold air through it. It muſt be carefully kept open, and cleanſed from the ſcoria, which would be apt to block its cavity, by which not only the heat would be too much diminiſhed for the ſucceſs of the operation, but the tube itſelf would be melted.

To prepare for the fuſion, a quantity of ſcoria of a former operation is thrown into the fire-place, till one-third part of this be full; and the remaining two-thirds of the fire-place are to be filled with ſmaller ſcoria, coal duſt, and ſparks ejected from hot iron. Theſe matters, being fuſible, form a bath for the reception of the iron when melted. Upon this bed of ſcoria, the maſs of caſt-iron to be melted is placed; ſo that one end of it ſhall be within the fire-place, oppoſite to the tuyere, and at the diſtance of about four or five inches from its aperture; and the other end ſhall ſtand without the fire-place, to be puſhed in, as the former is melted. The upper ſide of the maſs of iron ought to be in the ſame horizontal plane as the upper part of the orifice of the tuyere, that the wind may, by means of the obliquity of its courſe, ſtrike upon and paſs along the underſide of the maſs: but if the iron be difficultly fuſible, the tuyere is to be diſpoſed more horizontally, ſo that the wind ſhall ſtrike directly upon the maſs of iron; and that one part of the blaſt ſhall graze along the upper ſurface, and the other part along the under ſurface of the iron.

charine juices; the extractive matter of plants, properly so called, are saponaceous substances, or acid soaps. In many of these soaps, such as essential

iron. The mass of iron weighs generally from two hundred to four hundred pounds. Sometimes two or three smaller masses are put one above another, so as not to touch. When these are of different qualities, the cold-short piece is placed undermost, that being more unfusible than the red-short. The iron being placed, charcoal-powder is thrown on both sides, and coals are accumulated above, so as to cover entirely the iron.

The coals are then to be kindled, and the bellows are made to blow, at first slowly, and afterwards with more and more force. The iron is gradually liquefied, and flows down in drops through the melted scoria to the bottom of the fire-place; during which the workmen frequently turn the iron, so that the end opposed to the blast of wind may be equally exposed to heat, and uniformly fused. While the coals are consumed, more are thrown on, so that the whole may be kept quite covered. During the operation, a workman frequently sounds the bottom and corners of the fire place, by means of a bar or poker, raises up any mass of metal which he finds adhering to these, and exposes them to the greatest heat, that they may be more perfectly fused.

When all the iron is fused, no more coals are to be added; but the melted mass is to remain half uncovered for some time; during which the iron boils and bubbles, and its surface swells and rises higher and higher. When the iron has risen as high as the upper edge of the fire place, the coals upon its surface must be removed; and by thus exposing it to cold air, its ebullition and swelling subside. In this state, or coction, the iron is kept during half an hour or more, by adding occasionally pieces of good coal, which maintain a sufficient heat, without covering entirely the surface of the mass. During this coction, the workmen allow the orifice of the tuyere to be half stopped up by the scoria, that the air may not blow upon the iron with all its force, by which it would be too much cooled. Accordingly, when they think that the coction has continued sufficiently long, they clear the passage of the tuyere, and the mass is soon cooled by the cold air. At the same time also, they open a passage in the eye of the hammer placed in the front of the fire place, through which some of the scoria is allowed to flow out. When the iron has become solid, the bellows are stopt, the coals are removed, and the mass is left during an hour; and then the workmen raise it from the fire-place, turn it upside down, and proceed to the second coction or fusion of the iron.

For this second operation, the mass is to be so placed, that one part of it shall rest upon the tuyere, and the other upon the scoria remaining in the fire-place. This scoria is to be disposed in an oblique direction parallel to the tuyere, by which means the wind of the bellows is obliged to pass all along the under side of the mass of iron. About the sides of the mass, charcoal powder and burnt ashes are thrown; but towards the tuyere, dry and entire pieces of coals are placed, to maintain the fire. When these are kindled, more coals are added, and the fire is gradually excited. The workman attends to the direction of the flame, that it pass equally along the under surface of the iron, quite to the further extremity, and that it do not escape at the sides, nor be reverberated back towards the tuyere, by which this copper tube might be melted. During this fusion, pieces of iron are apt to be separated from the mass, and to fall down unfused to the bottom and corners of the fire-place. These are carefully to be searched for, and exposed to the greatest heat till they are melted. When the whole mass is thus brought into perfect fusion, the coals are removed, and the wind blowing on its surface, whirls and dissipates the small remaining pieces of scoria, and sparks thrown out from the fluid iron. This jet of fire continues about seven or eight minutes, and the whole operation about two hours. In this second fusion the scoria is to be thrice removed, by opening a passage through the eye of the hammer. The first time of removing the scoria is about twenty minutes from the kindling of the fire; the second time is about forty minutes after the first; and the third time is near the end of the operation.

The mass is then removed from the hearth, and

ſalts and vegetable acids, the ſaline part predominates over the oily part, and they have therefore been conſidered rather as ſalts, than as ſoaps. But the oil

and put upon the ground of the forge, where it is cleanſed from ſcoria, and beat into a more uniform ſhape. It is then placed on an anvil, where, by being forged, it receives a form nearly cubical. This maſs is to be divided into five, ſix, or more pieces, by means of a wedge; and theſe are to be heated and forged till they are reduced to the form of the bars, commonly ſold.

In ſome forges, the iron is fuſed only once, and in others it ſuffers three fuſions, by which it is ſaid to be rendered very pure. Where only one fuſion is practiſed, it is called the *French method*. In this, no greater quantity of iron is fuſed at once than is ſufficient to make one bar. The fireplace is of conſiderably leſs dimenſions, and eſpecially is leſs deep than in the German method above deſcribed. The fire is alſo more intenſe, and the proportion of fuel conſumed to the iron is greater. The iron, when melted, is not kept in a ſtate of ebullition as is above deſcribed; but this ebullition is prevented by ſtirring the fluid maſs with an iron bar, till it is coagulated, and becomes ſolid.

By theſe operations, fuſion and forging, the iron loſes about $\frac{3}{11}$ parts of its former weight, ſometimes more and ſometimes leſs, according to the quality of the caſt iron employed; it is purified from the vitreous and earthy parts which were intermixed with it, its metallic particles are more cloſely compacted, its texture is changed, and it is rendered more denſe, ſoft, malleable, tough, and difficultly fuſible.

The degrees however of theſe qualities vary much in different kinds of iron. Thus ſome iron is tough and malleable, both when it is hot and when it is cold. This is the beſt and moſt uſeful iron. It may be known generally by the equable ſurface of the forged bar, which is free from tranſverſe fiſſures or cracks in the edges, and by a clear, white, ſmall-grained, or rather fibrous texture. Another kind is tough when it is heated, but brittle when it is cold. This is called *cold-ſhort* iron, and is generally known by a texture conſiſting of large, ſhining plates, without any fibres. It is leſs liable to ruſt than other iron. A third kind of iron, called *red-ſhort*, is brittle when hot, and malleable when cold. On the ſurface and edges of the bars of this kind of iron, tranſverſe cracks or fiſſures may be ſeen; and its internal color is dull and dark. It is very liable to ruſt. Laſtly, ſome iron is brittle both when hot and when cold.

Moſt authors, agree that the red-ſhort quality of iron proceeds from ſome ſulphur or vitriolic acid being contained it, becauſe ſulphur is known to produce this effect when added to iron; and becauſe the iron obtained from pyritous and other ſulphurated ores has generally this quality.

The cauſe of the cold-ſhort quality of iron is not ſo well aſcertained. Some imagine that it proceeds from a mixture of arſenic or of antimony. But this opinion ſeems to be improbable, when we conſider that theſe metallic ſubſtances may in a great meaſure be diſſipated by roaſting, whereas the ores which yield a cold-ſhort iron are injured by much roaſting; that no arſenic or antimony are obſervable in moſt, if in any, of theſe ores; and laſtly, that theſe ſemi-metals would render the iron brittle both when hot and when cold. Cramer and other authors impute this vicious quality to a mixture of an unmetallic earth or vitreous matter, and affirm that it may be deſtroyed by cementation with phlogiſton, and by forging. And laſtly, others aſcribe the cold-ſhort quality of iron to a defect of phlogiſton, or, as Suedenborgius ſays, of ſulphur. To aſcertain the cauſes of the bad qualities of iron, and to diſcover practicable remedies, are ſtill deſiderata in metallurgy.

In one bar frequently two or more different kinds of iron may be obſerved, which run all along its whole length: and ſcarcely a bar is ever found of entirely pure and homogeneous iron. This difference probably proceeds from the practice we have mentioned of mixing different kinds of ores together, in the ſmelting; and alſo from that practice of mixing two or more pigs of caſt iron of different qualities in the finery of theſe: by which means, the red-ſhort and the cold-ſhort qualities of the different kinds are not, as we have already remarked, mutually counteracted or deſtroyed by each other, but each of theſe qualities is diminiſhed in the mixed maſs of iron, as much as this

contained in all these compounds is rendered perfectly miscible with water by means of the saline matter, and it is consequently in a state truly saponaceous.

this mass is larger than the part of the mass originally possessed of that quality: That is, if equal parts of red-short and of cold-short iron be mixed together; the mixed mass will be only half as red-short as the former part, and half as cold-short as the latter. For these different kinds of iron seem as if they were only capable of being interwoven and diffused through each other, but not of being intimately united or combined.

Of the SMELTING *of* TIN-ORES.

The tin-ores commonly smelted are those which consist of calx of tin combined with calx of arsenic and sometimes with calx of iron. These are either pure, as the tin-grains, or intermixed with spars, stones, pyrites, ores of copper, iron, or of other metals.

The impure ores must be *cleansed* as much as is possible from all heterogeneous matters. This cleansing is more necessary in ores of tin than of any other metal, because in the smelting of tin-ores a less intense heat must be given than is sufficient for the scorification of earthy matters, lest the tin be calcined. Tin-ores previously bruised may be cleansed by washing, for which operation their great weight and hardness render them well adapted. If they be intermixed with very hard stones or ferruginous ores, a slight roasting will render these impure matters more friable, and consequently fitter to be separated from the tin-ores. Sometimes these operations, the roasting, contusion, and lotion, must be repeated. By roasting, the ferruginous particles are so far revived, that they may be separated by magnets.

The ore, thus cleansed from adhering heterogeneous matters, is to be *roasted* in an oven or reverberatory furnace with a fire rather intense than long continued, during which it must be frequently stirred to prevents its fusion. By this operation, the arsenic is expelled, and in some works is collected in chambers built purposely above the calcining furnace.

Lastly, the ore cleansed and roasted is to be *fused*, and reduced to a metallic state. In this fusion, attention must be given to the following particulars. 1. No more heat is to be applied than is sufficient for the reduction of the ore, because this metal is fusible with very little heat, and is very easily calcinable. 2. To prevent this calcination of the reduced metal, a larger quantity of charcoal is used in this than in most other fusions. 3. The scoria must be frequently removed, lest some of the tin should be involved in it, and the melted metal must be covered with charcoal powder to prevent the calcination of its surface. 4. No flux or other substance, excepting the scoria of former smeltings which contains some tin, are to be added, to facilitate the fusion.

SMELTING *of* ORES *of* LEAD.

Ores of lead are either *pure*, that is, containing no mixture of other metal; or they are *mixed* with silver, copper, or pyrites. The methods of treating ores of lead containing silver and copper, are described in the articles SMELTING *of* ORES *of* SILVER and *of* COPPER; and in the former of these articles, an instance is given of the method of smelting the ore of Rammelsberg, which contains all these three metals.

Pure ores of lead, and those which contain so small a quantity only of silver as not to compensate for the expence of extracting the nobler metal, may be smelted in furnaces, and by operations similar to those used at Rammelsberg, or in the following methods. 1. From the lead-ore of *Willach* in *Carinthia*, a great part of the lead is obtained by a kind of *eliquation*, during the roasting of the ore. For this purpose, the ore is thrown upon several strata or layers of wood, placed in a calcining or reverberatory furnace. By kindling this wood, a great part of the lead flows out of the ore, through the layers of fuel, into a bason placed for its reception. The ore which is thus roasted is beat into smaller pieces, and exposed to a second operation similar to the former, by which more metal

metal is eliquated; and the remaining ore is afterwards ground, washed, and smelted in the ordinary method.

The lead of Willach is the purest of any known. Schlutter ascribes its great purity to the method used in extracting it, by which the most fusible, and consequently the purest part of the contained lead is separated from any less fusible metal which happens to be mixed with it, and which remains in the roasted ore. This method requires a very large quantity of wood.

2. In England, lead-ores are smelted either *upon a hearth*, or *in a reverberatory furnace*, called *a cupol*.

In the first of these methods, charcoal is employed as fuel, and the fire is excited by bellows. Small quantities of fuel and of ore are thrown alternately and frequently upon the hearth. The fusion is very quickly effected; and the lead flows from the hearth as fast as it is separated from the ore.

3. In the second method practised in England, pit-coal is used as fuel. The furnace is represented by *Fig.* 14. *and* 15. PLATE II. The ore is melted by means of the flame passing over its surface; its sulphur is burnt and dissipated, while the metal is separated from the scoria, and collected at the bottom of the furnace. When the ore is well cleansed and pure, no addition is requisite; but when it is mixed with calcareous or earthy matrix, a kind of fluor or fusible spar found in the mines is generally added to render the scoria more fluid, and thereby to assist the precipitation of the metal. When the fusion has been continued about eight hours, a passage in the side of the furnace is opened, through which the liquid lead flows into an iron cistern. But immediately before the lead is allowed to flow out of the furnace, the workmen throw upon the liquid mass a quantity of slaked quicklime, which renders the scoria so thick and tenacious, that it may be drawn out of the furnace by rakes. Schlutter mentions this addition of quicklime in the smelting of lead-ores in England, but thinks that it is intended to facilitate the fusion of the ore, whereas it really has a contrary effect, and is never added till near the end of the operation, when the scoria is to be raked from the surface of the metal.

Of the SMELTING *of* ORES *of* SEMIMETALS.

ANTIMONY is obtained by a kind of eliquation from the minerals containing it, as is described in the article ANTIMONY: and the regulus of antimony is procured from antimony, by the processes described in the same *article*, and in the article REGULUS *of* ANTIMONY.

ARSENIC, SAFFRE, and BISMUTH are obtained generally from one ore, namely, that called *cobalt*. The arsenic of the ore is separated by roasting, and adheres to the internal surface of a chimney, which is extended horizontally about two or three hundred feet in length, and in the sides of which are several doors, by means of which the arsenic, when the operation is finished, may be swept out and collected. These chimneys are generally bent, in a zig-zag direction, that they may better retard and stop the arsenical flowers. These flowers are of various colors, white, grey, red, yellow, according to the quantity of sulphur or other impurity with which they happen to be mixed. They are afterwards purified by repeated sublimations; while some alkaline or other substances are added to detain the sulphur, and to assist the purification.

In the same roasting of the ore by which the arsenic is expelled, the bismuth, or at least the greatest part of this semimetal which is contained in the ore, being very fusible, and having no disposition to unite with the regulus of cobalt, which remains in the ore, is separated by eliquation.

The remaining part of the roasted ore consists chiefly of calx of regulus of cobalt, which not being volatile, as the arsenic is, nor so easily fusible as bismuth is, has been neither volatilized nor melted. It contains also some bismuth, and a small quantity of arsenic, together with any silver or other fixed metal which happened to be contained in the ore. This roasted ore being reduced to a fine powder, and mixed with three or four times its weight of fine sand, is the

powder

according to the ſtate and nature of the acids and oils combined. Vitriolic and nitrous acids, eſpecially when well concentrated, act ſo powerfully upon all drying, ſweet, or eſſential oils, that they produce conſiderable alterations. Nitrous acid inflames them, or, when not ſufficiently concentrated to produce this inflammation, it reduces them, as the vitriolic acid alſo does, into thick, reſinous, and bituminous compounds. The action of theſe acids appears leſs ſtrong upon the fat oils, which do not dry, and are capable of forming with them true acid ſoaps. But all theſe matters have been but ſuperficially examined, and may be conſidered, by perſons deſirous of extending chemical knowledge, as a new ſubject.

DCXXXIV. SOAP (COMMON). Common ſoap is a combination of oil of olives with fixed alkali rendered cauſtic by quicklime. Soap may be made by ſeveral methods, which however all depend upon the

powder called *ſaffre* or *zaffre*. *See* SAFFRE. Or the roaſted ore is ſometimes fuſed with about thrice its quantity of pure ſand and as much pure potaſh, by which a blue glaſs, called *ſmalt*, is produced (*ſee* SMALT), and a metallic maſs, called *ſpeiſs*, is collected at the bottom of the veſſel in which the matters are fuſed. The metallic maſs or ſpeiſs is compoſed of very different ſubſtances, according to the contents of the ore and the methods of treating it. The matters which it contains at different times are, nickel, regulus of cobalt, biſmuth, arſenic, ſulphur, copper, and ſilver.

Biſmuth is ſeldom procured from any other ores but that of cobalt. It might however be extracted from its proper ores, if a ſufficient quantity of theſe was found, by the ſame method by which it is obtained from cobalt, namely, by eliquation.

MERCURY, when native and inveloped in much earthy or other matter, from which it cannot be ſeparated merely by waſhing, is diſtilled either by aſcent, or by deſcent. When it is mineraliſed by ſulphur, that is, when it is contained in cinnabar, ſome intermediate ſubſtance, as quicklime, or iron, muſt be added in the diſtillation, to diſengage it from the ſulphur. *See* CINNABAR. The rich ore of Almaden in Spain is a cinnabar, with which a calcareous ſtone happens to be ſo blended, that no addition is required to diſengage the mercury from the ſulphur. The diſtillation is there performed in a furnace conſiſting of two cavities, one of which is placed above another. The lower cavity is the fire-place, and contains the fuel, reſting upon a grate, through the bars of which the air enters, maintains the fire, and paſſes into a chimney, placed at one ſide of the fire-place immediately above the door through which fuel is to be introduced. The roof of this fire place, which is vaulted and pierced with ſeveral holes, is alſo the floor of the upper cavity. Into this upper cavity the mineral from which mercury is to be diſtilled is introduced, through a door in one of the ſides of the furnace. In the oppoſite wall of this cavity are eight openings, all at the ſame height. To each of theſe openings is adapted a file of aludels connected and luted together, extending ſixty feet in length. Theſe aludels, which are earthen veſſels open at each end, and wider in the middle than at either extremity, (*ſee* ALUDEL *and* PLATE I.) are ſupported upon an inclined terras; and the aludel of each file, that is moſt diſtant from the furnace, terminates in a chamber built of bricks, which has two doors, and two chimneys.

When the upper cavity is filled ſufficiently with the mineral, a fire is made below, which is continued during twelve or fourteen hours. The heat is communicated through the holes of the vaulted roof of the fire-place to the mineral in the upper cavity, by which means the mercury is volatiliſed, and its vapor paſſes into the aludels, where much of it is condenſed, and the reſt is diſcharged into the brick-chamber, in which it circulates till it alſo is condenſed. If any air or ſmoke paſſes through the aludels along with the vapor of the mercury, they eſcape through the two chimneys of the chamber. Three days after the operation, when the apparatus is ſufficiently cooled, the aludels are unluted, and the doors of the chamber are opened, and the mercury is collected.

ſame

ſame principle. The ſoap which is uſed in medicine is made without heat in the following manner.

One part of quicklime and two parts of good Spaniſh ſoda are boiled together, during a ſhort time, with twelve times as much water, in an iron caldron. This lixivium is to be filtered, and evaporated by heat, till a phiol which is capable of containing an ounce of water, ſhall contain an ounce and three gros of this concentrated lixivium. One part of this lixivium is to be mixed with two parts of oil of olives, or of ſweet almonds, in a glaſs or ſtone-ware veſſel. The mixture is to be ſtirred from time to time with an iron ſpatula, or with a peſtle, and it ſoons becomes thick and white. The combination is gradually compleated, and in ſeven or eight days a very white and firm ſoap is obtained.

Soap is made with heat in manufactures where large quantities of it are prepared. A lixivium of quicklime and ſoda is made, but is leſs concentrated than that above deſcribed, and only ſo much that it can ſuſtain a freſh egg. A part of this lixivium is to be even diluted, and mixed with an equal weight of oil of olives. The mixture is to be put on a gentle fire, and agitated, that the union may be accelerated. When the mixture begins to unite well, the reſt of the lixivium is to be added to it, and the whole is to be digeſted with a very gentle heat, till the ſoap be completely made. A trial is to be made of it to examine whether the juſt proportion of oil and alkali has been obſerved. Good ſoap of this kind ought to be firm and very white when cold, not ſubject to become moiſt by expoſure to air, and entirely miſcible with pure water, to which it communicates a milky appearance, but without any drops of oil floating on the ſurface. When the ſoap has not theſe qualities, the combination has not been well made, or the quantity of ſalt or of oil is too great, which faults muſt be corrected.

In ſoft or liquid ſoaps, green or black ſoaps, cheaper oils are employed, as oil of nuts, of hemp, of fiſh, &c. Theſe ſoaps, excepting in conſiſtence, are not eſſentially different from white ſoap.

Any fixed alkalis are much diſpoſed to unite with oils that are not volatile, both vegetable and animal, ſince this union can be made even without heat. The compound reſulting from this union partakes at the ſame time of the properties of oil, and of alkali; but theſe properties are modified and tempered by each other, according to the general rule of combinations. Alkali formed into ſoap has not nearly the ſame acrimony as when it is pure; it is even deprived of almoſt all its cauſticity, and its other ſaline alkaline properties are almoſt entirely aboliſhed. The ſame oil contained in ſoap is leſs combuſtible than when pure, from its union with the alkali, which is an uninflammable body. It is miſcible or even ſoluble in water to a certain degree, by means of the alkali. Soap is entirely ſoluble in ſpirit of wine, and ſtill better in aqua vitæ ſharpened by a little alkaline ſalt, according to an obſervation of Mr. Geoffroy.

When oil unites with alkali in the formation of ſoap, it is little altered in the connexion of its principles, for it may be ſeparated from the alkali by decompoſing ſoap with any acid, and may be obtained nearly in its original ſtate. By the accurate inveſtigation that Mr. Geoffroy has made of ſoap, by decompoſing it thus by means of an acid, he found that two ounces of this compound conſiſt of one ounce, three gros and one ſcruple of oil, one gros and a ſcruple of

marine alkali deprived of all oil and moiſture, or twice the quantity of this ſalt containing the water of its cryſtallization, and, laſtly, two gros and four grains of water. This latter quantity of water is nevertheleſs variable, according to the condition of the ſoap; for it may be much more or much leſs dry.

Concerning the decompoſition of ſoap by means of acids we muſt obſerve, firſt, that all acids, even the weakeſt vegetable acids, may occaſion this decompoſition, becauſe every one of them has a greater affinity than oil with fixed alkali. Secondly, theſe acids, even when united with any baſis, excepting a fixed alkali, or the inflammable principle, are capable of occaſioning the ſame decompoſition; whence all ammoniacal ſalts, all ſalts with baſis of earth, and all thoſe with metallic baſes, are capable of decompoſing ſoap, in the ſame manner as diſengaged acids are; with this difference, that the oil ſeparated from the fixed alkali, by the acid of theſe ſalts, may unite more or leſs intimately with the ſubſtance which was the baſis of the neutral ſalt employed for the decompoſition.

Soap may alſo be decompoſed by diſtillation, as Lemery has done. When firſt expoſed to fire, it yields a phlegm called by him a ſpirit; which nevertheleſs is neither acid nor alkaline, but ſome water which enters into the compoſition of ſoap. It becomes more and more colored and empyreumatic as the fire is encreaſed, which ſhews that it contains the moſt ſubtle part of the oil. It ſeems even to raiſe along with it, by help of the oil and action of the fire, a ſmall part of the alkali of the ſoap: for, as the ſame chemiſt obſerves, it occaſions a precipitate in a ſolution of corroſive ſublimate. After this phlegm, the oil riſes altered, preciſely as if it had been diſtilled from quicklime, that is, empyreumatic, ſoluble in ſpirit of wine, at firſt ſufficiently ſubtle and afterwards thicker. An alkaline reſiduous coal remains in the retort, conſiſting chiefly of the mineral alkali contained in the ſoap, and which may be diſengaged from the coal by calcination in an open fire, and obtained in its pure ſtate.

As all oils contain an acid more or leſs combined, which may alſo be more or leſs diſengaged by the oil becoming rancid, by the action of heat, or by combination with other bodies, probably a portion of the alkali of the ſoap is ſaturated with the acid of the oil, eſpecially after the diſtillation of the ſoap. But this matter has not been ſo well examined, that we can affirm any thing concerning it.

Alkaline ſoaps are very uſeful in many arts and trades, and alſo in chemiſtry and medicine. Their principal utility conſiſts in a deterſive quality that they receive from their alkali, which, although it is in ſome meaſure ſaturated with oil, is yet capable of acting upon oily matters, and of rendering them ſaponaceous and miſcible with water. Hence ſoap is very uſeful to cleanſe any ſubſtances from all fat matters with which they happen to be ſoiled. Soap is therefore daily uſed for the waſhing and whitening of linen, for the cleanſing of woolen-cloths from oil, and for whitening ſilk and freeing it from the reſinous varniſh with which it is naturally covered. Pure alkaline lixiviums being capable of diſſolving oils more effectually than ſoap, might be employed for the ſame purpoſes; but when this activity is not mitigated by oil as it is in ſoap, they are capable of altering and even of deſtroying entirely by their cauſticity moſt ſubſtances, eſpecially animal matters, as ſilk, wool, and others: whereas ſoap

cleanses from oil almost as effectually as pure alkali, without danger of altering or destroying, which renders it very useful.

Soap furnishes medicine with a very efficacious and valuable remedy. Til lately, that Mrs. Stephen's lithontriptic remedy has been published, physicians attended little to the medicinal qualities of soap. They soon found that soap, which is the principal ingredient of this famous remedy, is also the only one which has any real efficacy. And although this remedy has been found to be insufficient to dissolve most stones of the bladder, yet experience and observation have sufficiently evinced that it can prevent the enlargement, or even the formation, of stones in persons disposed to that disease; that it can, in a word, attenuate, divide, and expel the stoney particles generated in the urinary passages, and which are the first materials of the stone. And accordingly soap is frequently used successfully in these cases. When soap was once discovered to act sensibly on the glue or binding substance of that urinary sand, gravel, and even of some stones, it was naturally supposed to be capable of acting more powerfully on other thickened matters, which are too frequent causes of many obstinate diseases. These considerations have induced the best practitioners to prescribe soap as a resolving, aperitive, and deobstruent remedy; and we are certain that it has been employed as such with great success.

From the properties of soap we may know that it must be a very effectual and convenient anti-acid. It absorbs acids as powerfully as pure alkalis and absorbent earths, without having the causticity of the former, and without oppressing the stomach by its weight, like the latter.

Lastly, we may perceive that soap must be one of the best of all antidotes to stop quickly, and with the least inconvenience, the bad effects of acid corrosive poisons, as aqua fortis, corrosive sublimate, &c.

DCXXXV. SOAP (STARKEY's). This preparation is a combination of fixed vegetable alkali with essential oil of turpentine. It is named from the inventor, a chemist, called Starkey, who endeavoring to resolve the problem of the volatilisation of salt of tartar, combined that alkali with several substances; and particularly with oil of turpentine, and remarked that from this latter mixture a saponaceous compound was formed, which has been supposed to possess many medicinal virtues. It enters into the composition of pills, named also from Starkey. The belief of its good qualities has induced persons to continue the preparation of this soap, and to endeavor, but without success, to improve the process.

Although fixed alkalis are not absolutely inactive upon essential oils, they cannot however unite as easily with these, as with sweet oils, which are not volatile. If we attempt to combine any essential oil, and particularly oil of turpentine, with liquid fixed alkali, as in the preparation of ordinary soap, we shall soon find that these two substances cannot unite, or only imperfectly, and in long time. Starkey found no other expedient for the preparation of his soap than time and patience. His method, which is perhaps the best of all, consists in putting dry alkali into a matrass, and pouring upon it essential oil of turpentine to a height equal to the breadth of two or three fingers. In a long time the combination was compleated. In five or six months a part of the alkali and oil are thus combined together, and form a sort of white saponaceous compound. This soap

 must

muſt be ſeparated from the mixture, and more of it will be afterwards formed in the ſame manner.

Shorter methods have been ſearched for the preparation of this ſoap, by ſeveral chemiſts; and amongſt theſe is the illuſtrious Stahl; who conſidering water as part of the combination of every ſoap, and even that it is a medium by which the ſalt and oil are united together, directs that after having mixed oil of turpentine with very hot alkali, and having ſhook them together, this mixture ſhould be expoſed in a moiſt place, that all the portion of alkali which does not unite with the oil may deliquiate, and be ſeparated from the part of the mixture that is combined; that this alkali ſhould then be dried, and new oil poured upon it, as at firſt; and, laſtly, that this method ſhould be continued till the whole be reduced into ſoap; and thus the operation will, as he affirms, be greatly ſhortened. Nevertheleſs, later chemiſts, not ſatisfied with this method of Stahl, have endeavoured to ſimplify ſtill more this operation. Mr. Rouelle the younger has publiſhed in the *Journal de Medicine*, that he has diſcovered a more expeditious method than all thoſe hitherto known for the preparation of this ſoap. Mr. Beaumé has alſo publiſhed in the *Gazette de Medicine* a method of making it in a few hours. It conſiſts in triturating, during a long time, alkaline ſalt upon a porphyry, and in adding to this ſalt, during the trituration, oil of turpentine. According to this able chemiſt, the thick reſinous part only of this oil can truly combine with fixed alkali: and this combination is effected only while the more volatile and attenuated part of the oil is diſſipated. For which reaſon, according to him, a very great quantity of oil of turpentine is requiſite for the formation of Starkey's ſoap, which quantity of oil is indeterminate, as, the more volatile and ethereal it is, the more of it is required; and alſo the trituration upon the porphyry, by promoting the evaporation of the ſubtle part of the oil, accelerates conſiderably the operation of Starkey's ſoap.

Another artiſt ſays, in the *Gazette de Medicine*, that the operation may be much abridged, by adding to the new mixture a certain quantity of this ſoap ready made; which correſponds with Mr. Beaumé's opinion. Laſtly, Mr. Beaumé has found, that the addition of a little turpentine, or of ordinary ſoap, conſiderably abridges the operation; and this alſo confirms his opinion, which ſeems to be very probable. We do not mean to blame the zeal of theſe chemiſts in making ſo many attempts to find a method of preparing this ſoap quickly, but we confeſs that the importance of the object does not ſeem adequate to their trouble. For, in fact, what does it ſignify whether this ſoap, not uſed in the arts, and but little in medicine, be quickly or ſlowly made? The eſſential point is not that it be quickly, but well done.

And to ſpeak our ſentiments freely, this preparation ſeems to be uncertain and ill-choſen. For, beſides that the true ſoap of Starkey, that is, the intimate combination of ethereal oil of turpentine with fixed alkali, according to the uſual idea of it, is a thing probably impoſſible, we believe that we may affirm, that the ſaponaceous compounds obtained by any method of mixing oil of turpentine with fixed alkali do not long remain in the ſame ſtate, and by time neceſſarily undergo perpetual alterations.

To be fully convinced of this truth, we may compare together not only theſe ſoaps made by different proceſſes, but alſo the ſame ſoap, a longer or a ſhorter

time

time after it has been made, and we ſhall find conſiderable differences in their color, ſmell, and conſiſtence. We ſhall find that thoſe deliquiate, and are partly reſolved into liquor by the air, that have been made with a too ethereal oil, which is incapable of ſaturating well the fixed alkali; that others acquire by time a pitchy, yellowiſh, ſemi-tranſparent and reſinous appearance, which contain too large a quantity of thick reſiduum of oil of turpentine. Thoſe ſoaps which ſeem to be the beſt made, which contain a proper quantity of oil of turpentine, which are neither too ethereal nor too thick, preſerve longer their white color and the conſiſtence of true ſoap: But they nevertheleſs participate more or leſs of the faults we have mentioned. Laſtly, all theſe ſoaps are liable to contain a conſiderable quantity of a ſort of neutral ſalt, formed by the acid of the oil of turpentine, united with a part of the alkali of the ſoap. This ſalt cryſtallizes upon the ſurface, and even within the ſoap, which in time becomes quite penetrated and ſtuck all over with a ſaline effloreſcence. Theſe bad qualities and alterations of Starkey's ſoap cannnot be avoided by any method, as they depend on the nature of eſſential oils, which we cannot change. Theſe ſoaps are known to contain a volatile and ſuperficially combined acid, which unfolds itſelf more and more, or which is engaged more intimately with a portion of oil, to which it gives a thicker conſiſtence. We are no leſs certain that the moſt ethereal part of eſſential oils, or their ſpiritus rector, is ſo volatile, that however attentive we may be to preſerve it, it will gradually diſſipate in time: in a word, we know from experience, that all eſſential oils are drying, and are much more ſpontaneouſly alterable than any others; and that theſe ſpontaneous alterations cannot be prevented by the imperfect combination which they are capable of forming with an alkali. On the contrary, this alkali, by abſorbing their acid, and by facilitating the diſſipation of their ethereal part, with which the alkali is not capable of forming a true union, can only haſten the alterations to which the oil is naturally diſpoſed.

From all this we ought to conclude, that Starkey's ſoap is a difficult, uncertain, variable preparation, which is continually changing its nature, and conſequently its medicinal virtues. This latter inconvenience, although it were the only one, would be ſufficient to make us reject this preparation. And therefore, if, as is probable, a ſaponaceous ſubſtance, partaking of the properties of fixed alkali and of an eſſential oil, would be uſeful in medicine; ordinary ſoap, incorporated extemporaneouſly with any quantity of eſſential oil which ſhall be judged proper, might be ſubſtituted inſtead of Starkey's ſoap. *See* OILS (ESSENTIAL).

DCXXXVI. SOAP-ROCK, *or* SOAP-STONE. *See* STEATITES.

DCXXXVII. SODA. *(r)*

DCXXXVIII. SOLUTION. Solution conſiſts in an union formed by the integrant parts of one body with the integrant parts of another body of a different nature; and as a new compound is the reſult of this union, we hence ſee that ſolution is nothing elſe than the act of combination.

As the integrant parts of one body cannot unite with thoſe of another, while

(r) *Soda* is a name given to the maritime plant *kali*, from the aſhes of which a conſiderable quantity of mineral alkali may be obtained; and alſo to the aſhes themſelves, or to an impure alkaline ſalt extracted from theſe. *See* KALI, *and* ALKALI (MINERAL).

they

they adhere together; therefore ſolution cannot be made till the aggregation of one of the two bodies at leaſt is broken. And as bodies whoſe aggregation is broken are neceſſarily in a ſtate of fluidity or of vapors, an axiom has been formed, *Corpora non agunt niſi ſint fluida*, or, Bodies do not act unleſs they be fluid.

The two bodies which unite in ſolution are uſually diſtinguiſhed by two different names. That body is generally called the *ſolvent* which by its fluidity or acrimony appears to be active; and the body which from its want of taſte or from its ſolidity appears to be altogether paſſive, is ſaid to be *diſſolved*. Thus, for example, when metal or marble is diſſolved in aqua fortis, theſe ſolid bodies are conſidered as being *diſſolved*, and aqua fortis as the *ſolvent*. But theſe expreſſions ought not to be taken literally, for they would give a very falſe idea of what really happens in ſolution. On the contrary, we are certain that any two bodies, which unite together in ſolution, reciprocally exerciſe their action one upon another, and that the union which reſults from it is only the effect of the mutual tendency which they have to each other: that thus, in the examples mentioned, the marble and metal act as much upon the nitrous acid as this does upon them; and that, if they differ in this reſpect, that body, whoſe ſpecific gravity is greateſt, acts moſt ſtrongly. Mr. Gellert, conſidering the thing in this point of view, affects to repreſent as *ſolvents* the bodies which are generally conſidered as *diſſolved*, and ſays, for inſtance, that *ſand diſſolves alkali*. Provided that we underſtand that the action of the combining bodies is mutual, it ſignifies little that we name the one *ſolvent*, and the other the body *diſſolved*: and even as the word *ſolution*, taken in its moſt proper ſignification, expreſſes the ſeparation of the integrant parts of a body, we ſeem to ſpeak more clearly and accurately when we call that body the *ſolvent*, whoſe integrant parts are already ſeparated before the ſolution, and that the *body diſſolved* whoſe integrant parts are only diſunited during the act of ſolution.

As the ſolution cannot be effected unleſs one of the two bodies at leaſt be fluid, and as ſolid bodies only become fluid by the interpoſition of the parts of ſome other fluid, ſuch as water and watery liquors, or fire, hence ſolution may be made either by the *humid* or by the *dry way*. The ſolutions in which the integrant parts of one of the two bodies, or of both, are diſtributed in an aqueous fluid, as, for inſtance, thoſe of acids, are *ſolutions by the humid way*; and thoſe ſolutions in which one or both bodies are rendered fluid by fire, as in vitrification, and in allays of metals with each other, are *ſolutions in the dry way*.

The ſolution of bodies is not perfect, unleſs each of the integrant parts of one body are united to one of the integrant parts of another. Hence if one of the two bodies be tranſparent, we ought to have, after the mutual ſolution, a tranſparent compound, as happens in the ſolutions of calcareous ſtones and acids, and of thoſe of earths by alkalis. As therefore the ſolution of ſoap in water is always a little opake and milky, it ought not to be conſidered as complete. The ſame may be ſaid of glaſſes that are not perfectly tranſparent. Their want of tranſparency always proceeds from the parts of the ſand or flint not having been ſufficiently diſſolved by the ſalt, or from their containing ſome

refractory matters, such as certain metallic calxes, particularly calx of tin, which resist the action of salts.

As the solution of two bodies by one another can only be effected by the attraction or tendency which their integrant parts have to each other, hence, after the solution, these parts are found to adhere together: hence also heavy bodies may be suspended in the thinnest and lightest liquids, when they are truly dissolved by each other. For instance, corrosive sublimate, which is very heavy, may be suspended by spirit of wine, which keeps it dissolved, altho' this liquor be very light. *See* COMPOSITION *and* COMBINATION.

DCXXXIX. SOOT. Soot is a collection of substances formed by the matter of the flame of inflammable bodies, but which have escaped combustion, from not having sufficient contact with the air. This matter, which fixes itself to the internal surface of chimneys, is always of a black color, more or less brownish. This color it receives from an oil that is burnt, and half reduced to the state of coal.

As all inflammable bodies undergo a total decomposition during their inflammation, all the volatile principles which they contain, and even a part of the fixed principles, by means of those which are volatile, are raised in vapors, some part of which burns with flame, is totally dissipated and destroyed, and another part is sublimed and adheres to the first cold bodies which it meets.

Soot is, as we have now observed, the portion of flame which is reduced to black smoke, and which has not been inflamed from want of sufficient contact with air. For if the vapors exhaling from an inflammable body strongly heated were so rarefied that each of their parts should be altogether surrounded by air, they would all burn with flame, and then we should have no smoke or soot, or at least this soot would not be black, and would contain nothing inflammable. For which reason, the greater quantity of air is admitted amongst bodies which burn with flame, the less smoke and soot we have; and also, the soot proceeding even from bodies of the same kind must be very different according to the manner in which they are burnt. In general, we can say nothing that will be constantly applicable to the nature and principles of soot, as its differences arise not only from the causes abovementioned, but also from the nature of the inflammable substances which produce it. Thus vegetables, from which little or no volatile alkali is obtained, must furnish a soot different from that of animal matters; and the soot of a pure oil must be different from that of a plant containing all its principles. But these differences have not yet been observed, because chemists have not attended to this subject.

We know only that the ordinary soot of chimneys has an acrid, bitter, empyreumatic, and disagreeable taste; that water can extract from it a dusky-colored matter, which shews that it contains saline, oily, saponaceous parts; that it is capable of being again burnt very vividly and with much flame, as when chimneys are set on fire.

If this soot be distilled in a retort, we obtain from it phlegm, volatile alkali, partly concrete and partly liquid, a black empyreumatic oil, and in the retort much coal remains, from which fixed alkali may be extracted by incineration and lixiviation. Some acid also may possibly be obtainable from certain soots;

and generally towards the end of the distillation, when the heat is strong, a little sal ammoniac is sublimed.

As every soot, even that which proceeds from vegetable matters, contains a good deal of volatile alkali, we may infer, that the principles of vegetables suffer, by combustion in an open fire, changes similar to those occasioned by putrefaction. Besides, the quantity of fixed coal which remains after the distillation of soot, and which furnishes a fixed alkali, together with much earth, by incineration, shows that a very considerable quantity of the fixed principles of inflammable bodies is carried off, and even raised to a great height, by means of their combustion with flame: but, as we have said, soots are very different; and the matter is but little known, and requires further researches.

DCXL. SORREL. (s)

DCXLI. SPAR. Naturalists and chemists have given this name to certain crystallized stones, more or less transparent, which generally do not strike fire with steel, and which are found plentifully within the earth, but more especially in mines of metals.

Under this general name many stones are comprehended; because they have the general properties we have mentioned, and because they resemble each other by the form of their crystallization, in which we always perceive shining plates, like mirrors; but some of these stones are very different from others.

Some spars are entirely soluble with effervescence in acids, forming selenites with vitriolic acid, deliquescent salts with nitrous and marine acids, and convertible into quicklime by calcination. These stones are justly called *calcareous spars*.

Others, although entirely similar to these in appearance, do not effervesce with acids, are calcinable as gypsum and selenites are, and are, in fact, true selenites composed of vitriolic acid and calcareous earths. These spars are essentially different from the former, and are *gypseous* or *selenitic spars*.

Other spars are neither calcareous nor selenitic, do not lose their transparency in the fire, and seem to be of the nature of *talc*.

Lastly, a kind of stone, crystallized in mirror-like plates like a true spar, is almost opake, is indissoluble by acids, and is so much harder than all other spars as to be capable of striking fire with steel. This stone is fusible without addition, by the action of a violent fire, into a semi-transparent white matter. This seems to be the kind that Mr. Wallerius, Mr. Pott, and other German authors, call *fusible spars*. They also mention another spar which is compact, breaks like glass, and melts without addition. From the descriptions given by most authors we cannot easily discover what they mean by fusible spar, and by *quartz-spar*. These matters have not yet been sufficiently examined.

From the properties of all the substances called spars we may conjecture, that they are stones of all kinds, very different from each other, which being formed in metallic grounds, have contracted, either by the mixture of some metallic

(s) SORREL. The leaves of this plant contain an acid salt which may be obtained from the expressed juice by crystallisation. From twenty pounds of fresh sorrel-leaves Neuman expressed six pounds of juice, from which two ounces, two drams and one scruple of crystallised salt, together with two ounces and six drams of an impure saline mass, were obtained. See SALT (ESSENTIAL) of SORREL.

earths,

earths, or even by a metallization begun in their own earth, ſome properties common to all, or, at leaſt, to the greateſt number.

Thoſe properties are, 1. A certain form of ſhining laminæ in their cryſtallization, which appears even in thoſe, the figure of whoſe cryſtals ſeems leaſt diſpoſed to receive this form, as in thoſe which are ſtriated; for ſparry laminæ are diſtinguiſhable at the extremities of the ſtriæ, or bundles of ſtriæ, of which theſe ſpars are compoſed.

2. A greater ſpecific gravity than of all other ſtones. Some ſpars, eſpecially thoſe called *heavy ſpars*, are ſo very heavy, that they come near in this reſpect to metals.

3. A greater fuſibility than of other ſtones; for, beſides thoſe ſpars which are fuſible without addition, the mixture of ſpars facilitates the fuſion of moſt other earths and ſtones, and they are accordingly uſed as fluxes in the ſmelting of moſt metallic ores. Probably for this reaſon theſe ſtones have been called *fluors* by many mineralogiſts and metallurgiſts.

Laſtly, many ſpars are found colored by metallic principles, and imitate the colors of the ſeveral precious ſtones, although they are leſs beautiful and vivid.

We ſhall not enter into a more particular detail concerning ſpars, becauſe what is further known about them rather belongs to natural hiſtory than to chemiſtry; beſides that our knowledge of ſpars is very indiſtinct. (*t*)

(*t*) Spars. This name is given to many ſtones of different properties and appearances, which do not poſſeſs conſtantly any one common character or mark by which they may be certainly diſtinguiſhed from other ſtones. In general, we may obſerve, that they are moſt frequently found in mines, and that they generally conſiſt of ſmooth and ſhining plates or laminæ; that ſome are tranſparent, and others opake; that ſome are colorleſs, and others are colored; that they are cryſtallized in various determinate figures, or poſſeſs no determinate ſhape; and, laſtly, that they differ ſo much in hardneſs, denſity, degree of fuſibility, and in their moſt eſſential chemical properties, that they cannot be conſidered as forming a diſtinct claſs of foſſil ſubſtances. We need not wonder, therefore, that authors, eſpecially thoſe who have not been much accuſtomed to the examination of foſſil bodies, ſhould have given very confuſed and erroneous deſcriptions of ſpars. Many of theſe have not been ſufficiently examined; but thoſe of which we have acquired ſome knowledge, we ſhall endeavor to diſtinguiſh into their ſeveral different kinds, [illegible] than is done [illegible].

The ſeveral [illegible] to which the name of ſpar has been given are, the calcareous, the gypſeous, the [illegible] ſpars, and [illegible] ſpar.

1. *Calcareous ſpars* are ſoft, heavy ſtones, which have the common chemical properties of calcareous earth. Their texture is laminated. Some of them have no determinate figure, and others from their form are called *rhomboidal*. Some ſpars, called *dog's-tooth-ſpar*, have a pyramidal figure; but when theſe are broken, their fragments ſhow that they alſo conſiſt of rhomboidal particles.

Some rhomboidal ſpars are tranſparent, others are opake; ſome are colorleſs, and others are colored; laſtly, ſome of them have a ſingular property of refracting doubly the rays of light which paſs through them, and thereby of repreſenting any object, as, for inſtance, the letters of a book, ſeen through it, double. This ſpar has been called *Iſland cryſtal*, or *refracting ſpar*. Its figure is that of an oblique parallelopiped, contained within ſix parallelogram ſides and eight ſolid angles. Each of the obtuſe angles of the parallelograms is 101 degrees and 52 minutes; and each of the acute angles is 78 degrees and 8 minutes. Theſe are the dimenſions given by Sir Iſaac Newton of the angles of the ſides of the refracting ſpar; and I have found them to correſpond exactly with thoſe which I have ſeen.

Calcareous ſpars may be diſtinguiſhed from others by effervеſcing with acids.

2. *Gypſeous or ſelenitic ſpars.* Theſe are gypſcous

DCXLII. S P E L T E R. Zinc is sometimes so called. *See* ZINC.

DCXLIII. S P E R M A - C E T I. (*u*)

DCXLIV. S P I R I T. The name of spirit is given in general to al liquors obtained from substances by distillation. Spirits are of three principa kinds, namely, *inflammable spirits*, *acid spirits*, and *alkaline spirits*.

The class of inflammable spirits includes the most volatile and thinnest par of essential oils; the principle of smell, or the *spiritus rector* of plants; anc *ardent spirits*, or the spirit obtained from wine, beer, and all liquors whicl have undergone the *spirituous fermentation*.

In the second class are all acids obtained by distillation of minerals, vege tables, and of animals. Such are, 1, the acids of sulphur, vitriol, alum, al which are the same acid, namely, the vitriolic, and the acids of nitre and o common salt. They are called *spirit of sulphur*, *spirit of vitriol*, *spirit of nitre* &c. without specifying that they are acids. 2. The acids of *vinegar*, and o all liquors which have undergone the *acetous fermentation*, and the acids obtainec in the distillation of vegetables, and of certain animals, as flies, ants, &c These spirits are commonly called *acid spirits*, as the *acid spirit of guiacum*, th *acid spirits of ants*, &c. because the substances which furnish them yield alsc spirits that are not acid.

gypseous earth, distinctly crystallized. The form of the crystals is rhomboidal. They are also called *selenites* and *glacies Mariæ*. Sometimes these spars assume other forms. They are very heavy. *See* SELENITES, *and* GLACIES MARIÆ.

3. *Fusible spars*, called also *fluors*. Under this name many stones are comprehended of different shapes, appearances, and perhaps properties. Their general properties are described under the article FLUOR. They are most frequently found in mines, and are much used to facilitate the fusion of ores. Several fluors acquire a phosphoric property by calcination with inflammable matters. Such is the *Bolognian stone*; and also other white, heavy, friable, fusible spars, as Mr. Margraaf found. This chemist discovered, by analysing the Bolognian stone, and other fusible spars capable of receiving a phosphoric quality, that they consist of a gypseous earth united with a small quantity of clay. He also found, that several fusible spars could not receive the phosphoric quality of the Bolognian stone. What the cause of this difference is, and whether they all consist of the same constituent parts as those analysed by Mr. Margraaf, has not yet been discovered. *See* FLUOR.

4. *Felt-spar*, *Spatum scintillans*. This stone differs from all the foregoing, in being so hard as to be capable of striking ignitec sparks from steel. For which reason it i referred by Cronstedt to the siliceous clas of earths, and is by him called *rhombic quartz*; because the particles of which it consist seem to be parallelopipeds, each of which i contained within six rhombic or rhomboida sides. Its colors are various, white, grey and red.

Several other fossil substances consist o large plates, and are therefore said to havc a *sparry texture*. Such are some kinds o talk, of horn-blend, of quartz, of amianthus, and some calciform ores of metals.

(*u*) SPERMA-CETI is a white, flaky, unctuous substance, obtained from the head of whales. It is altogether soluble in oils; but is not capable of being dissolved by caustic alkalis, and of forming soaps, a other oily matters may. By distillation i may be entirely raised, without leaving any residuum. From four ounces of sperma-ceti three ounces and a half of oil, and a drachm and a half of phlegm, were distilled. The oil distilled is not black, fetid, and empyreumatic, like that of other animal substances, but clear, yellowish, and of the consistence of butter. Sugar does not render sperma-ceti perfectly miscible with water: but this may be better done by means o yolks of eggs. *Neuman.*

Lastly,

Laſtly, in the third claſs are liquid volatile alkalis, obtained from ſal ammoniac, from all vegetable matters which have undergone a compleat putrefaction, and from all animal matters. They are generally called *ſpirits* only, without ſpecifying their alkaline quality. Thus we ſay, *volatile ſpirit of ſal ammoniac, ſpirit of hartſhorn*, &c. As ſome of theſe ſubſtances, particularly ſal ammoniac, contain alſo an acid which may be obtained from them, we ought, when we mention this ſpirit, to ſpecify its acid quality, and to name it, for inſtance, *acid ſpirit of ſal ammoniac*.

DCXLV. SPIRIT (ARDENT). Ardent ſpirit, called alſo *ſpirit of wine*, becauſe it can be only obtained from ſubſtances which have undergone the vinous fermentation, is a very light, very volatile, very fluid liquor, perfectly white and limpid, and of a ſtrong, penetrating, agreeable taſte and ſmell.

This ſpirit may be eaſily inflamed, without being previouſly heated. Its flame is light, white in the center, blue at its edges, and not very luminous. It is not accompanied with any ſmoke or ſoot. It burns without noiſe, and without any ſuffocating or other vapors.

Spirit of wine perfectly pure, for of that I ſpeak, burns alſo entirely, with concurrence of free air, without leaving the leaſt veſtige of coal, or of any ſaline, earthy, or other reſiduum.

Although ſpirit of wine be altogether inflammable, it is nevertheleſs miſcible with water without any intermediate ſubſtance, and in all proportions, which is a ſpecific character of this liquor; for it is the only ſubſtance of the kind known which is poſſeſſed of theſe properties.

If ſpirit of wine be expoſed to heat in cloſe veſſels, it does not inflame, but is eaſily reduced into vapors which paſs in diſtillation. Theſe vapors, when collected, are entirely the ſame ſpirit of wine as before diſtillation, without having received any alteration or decompoſition, however frequently the operation may have been repeated.

Juncker ſays, that if ſpirit of wine be burnt in a tubulated retort, to which a large glaſs receiver has been adapted, it will be changed into a very ſubtle vapor, which condenſes in the receiver, and forms a liquor ſimilar to pure water.

Boerhaave affirms, that when the vapor of burning ſpirit of wine is collected by an apparatus of proper veſſels, it is nothing but very pure water.

The following are the principal properties of ſpirit of wine relatively to other ſubſtances.

It ſeems to have no ſenſible action upon earths, or upon metallic matters, nor even upon many neutral ſalts; but with acids, alkalis, and many oily ſubſtances it exhibits remarkable phenomena.

Spirit of wine unites with all acids; and by this union the acidity of theſe is diminiſhed. Accordingly, the acids thus combined with ſpirit of wine are called *dulcified acids*. See WATER *of* RABEL; SPIRIT *of* NITRE, *and* SPIRIT *of* SALT (DULCIFIED).

But when it is mixed in certain proportions with concentrated acids, and diſtilled, at leaſt, with moſt of them, it then receives from them, and produces upon them the following alterations.

First of all, some of it passes over dephlegmated as much as it can be without being essentially altered; afterwards it loses part of the water essential to it; consequently the nature of the remaining part is changed, and it is converted into a liquor, the properties of which shew, that it is as much approximated to the nature of oil as it is removed from that of spirit of wine. This liquor, which is very fluid and very volatile, is called *ether*, which is, according to what we have said, a substance exactly intermediate betwixt ardent spirit and oil. *See* ETHER.

After this, the spirit of wine, or its mixture with acids, acquires all the characters of oil, or rather becomes a genuine oil.

Acids, on their side, receive from spirit of wine, especially after the formation of ether, all the alterations which they usually receive from oils with which they have been treated and distilled. *See* ETHER.

Very strong and dephlegmated alkalis act singularly upon spirit of wine, and are even capable of decomposing it, when assisted by a certain degree of heat. They deprive it, first, of all its superabundant water, then of the water it contains as a principle, and, lastly, they reduce it to the condition of a true oil, without making it pass, as acids do, through the intermediate state of ether. *See* TINCTURE *of* SALT *of* TARTAR.

Spirit of wine is commonly considered as the solvent of oils and of oily matters; but properly it is the solvent only of one kind of oils. These are the essential oils and their concretions, such as balsams and resins; all which spirit of wine can dissolve. It attacks neither the fat oils nor the oily concretions analogous to them, as wax, butter, fat of animals, nor even certain substances which seem to partake more of the nature of true resins, as copal and bitumens. *See* OILS *and* RESINS.

When spirit of wine keeps an oily matter dissolved, it may be separated by distillation, if the oily matter be not volatile, or by diluting the solution with a large quantity of water. This water, with which the spirit has a greater affinity than with oil, unites with it, and renders it incapable of keeping the oil dissolved. Hence the oily matter separates at first in very small globules, which are dispersed through the liquor, and give it the white appearance of an emulsion; and these globules afterwards collect, forming more considerable masses, by which the liquor is rendered very clear.

These properties of spirit of wine are advantageously applied to extract the essential oils and resins of vegetable matters.

Accordingly, by digesting in spirit of wine aromatic plants, for instance, thyme, lavender, rosemary, &c. a spirituous liquor is obtained, impregnated with the principle of the smell, and with the essential oil of these plants. These spirituous aromatic waters, made by infusion, serve for several purposes in medicine. They are generally colored by a part of the resinous matter of the vegetables, which the spirit of wine also dissolves, or by substances of different colors which reside in the resinous substances. They have hence been called *tinctures*. *See* TINCTURES.

By distillation is obtained from spirituous tinctures a spirit of wine much impregnated with the principle of smell, and with the thinnest and most volatile part of the essential oils, but free from all extractive or coloring matter; because these latter are not sufficiently volatile to rise with spirit of wine. This

spiri-

ſpirit of wine is called by the general name *aromatic ſpirituous diſtilled water*, or only by the name of *water*, added to the name of the plant employed: hence the names of *lavender-water*, *roſemary-water*, &c. Waters are alſo made of ſeveral plants, and are diſtinguiſhed by particular names, as *vulnerary-water*, *imperial-water*, &c. All theſe waters are intended for medicine and for the toilette. We may find the details of theſe preparations in books on pharmacy, and particularly in *Mr. Beaume's Elements of Pharmacy*.

When a tincture has been diſtilled, we may find at the bottom of the veſſel the reſinous and extractive part which the ſpirit of wine had diſſolved. Theſe ſubſtances have undergone ſcarcely any alteration, becauſe they have been expoſed only to a very mild heat. Theſe are extracts of plants made by ſpirit of wine. *See* EXTRACT.

If, inſtead of ſubjecting to diſtillation the ſpirituous tinctures of vegetables, they be diluted with a large quantity of water, the reſinous part may be very well obtained pure and ſeparate from the extractive part. This latter part being equally ſoluble in water as in ſpirit, remains diſſolved notwithſtanding the addition of water, while the former part ſeparates, as we have ſaid, and forms a reſinous maſs.

By this method are obtained the reſins of jalap, of ſcammony, of guiacum, and of many other vegetable matters; and theſe reſins, not having undergone the action of fire, are not altered, but remain in the ſame ſtate in which they exiſted in the vegetables.

Spirit of wine diſſolves alſo very well certain ſalts, as ſal ammoniac, corroſive ſublimate, ſedative ſalt, and perhaps many others which we do not know of; becauſe this matter has not been much examined: but this ſpirit has little or no action upon other ſalts, as common ſalt, Glauber's ſalt, nitre, concrete volatile alkali, &c. It does not diſſolve matters purely gummy and gelatinous, or, at leaſt, it diſſolves but a ſmall quantity of them; and as all theſe matters are very ſoluble in water, and as water has a ſtronger affinity with ſpirit of wine than it has with theſe matters, hence this ſpirit may be employed to ſeparate theſe matters from water. For this purpoſe we need only to add a good deal of the ſpirit of wine to the water, which keeps them diſſolved: the ſpirit then ſeizes the water, and obliges the gummy, gelatinous, and ſaline parts which it contained in ſolution to ſeparate from it. The reverſe of all this paſſes in the ſeparation of oily and reſinous ſubſtances from ſpirit of wine by means of water. Spirit of wine coagulates the whites of eggs and animal lymph, by ſeizing upon the water which they contain.

The ſame may be ſaid of the coagulum formed by mixing ſpirit of wine with concrete volatile alkali, diſſolved by the ſmalleſt poſſible quantity of water. This coagulum, which is formed ſuddenly upon the mixture of theſe two liquors, and which is known in chemiſtry by the name *Offa Helmontii*, is nothing elſe than a ſudden cryſtallization of volatile alkali, occaſioned by the addition of ſpirit of wine, which ſeizes the water in which that alkali was diſſolved. The ſame may be ſaid of the cryſtallization of all ſalts, which may be inſtantaneouſly effected by the means of ſpirit of wine. *See* CRYSTALLIZATION.

From what has been ſaid, concerning the diſſolving power of ſpirit of wine, we may judge of its great utility in chemiſtry in extractions and ſeparations. It is particularly very uſeful in the analyſis of vegetables and animals by menſtruums.

ſtruums. By reflecting attentively on the properties of this ſolvent, many analyſes and ſeparations which tend to the progreſs and perfection of chemiſtry may be improved.

We ſhall finiſh this article by ſome reflexions on the nature of ſpirit of wine.

Stahl and moſt chemiſts believe, that ſpirit of wine is compoſed of a very attenuated and very light oil, intimately united by means of an acid with a larger quantity of water than that which enters as a principle in the combination of oil.

Juncker, on the contrary, appears to admit no other inflammable matter in ſpirit of wine than phlogiſton united with the aqueous principle by means of an acid.

Laſtly, Mr. Cartheuſer poſitively advances, that ſpirit of wine is compoſed of pure phlogiſton, not in an oily ſtate, but immediately united with the watery principle alone.

This diverſity of opinion amongſt the ableſt chemiſts proves, that the true principles of ſpirit of wine are not yet perfectly known. This proceeds from the difficulty of decompoſing it without an intermediate ſubſtance, and alſo from ſeveral phenomena, ſome of which ſeem to ſhew that it is not a true oil that enters as a principle into the compoſition of ſpirit of wine, but phlogiſton alone; while others ſeem to indicate the preſence of a true oil exiſting in the pureſt ſpirit of wine.

If we mix the beſt rectified ſpirit of wine with water, and if we allow it to evaporate ſlowly in open air, we ſhall find upon the ſurface of the water a certain quantity of oil; and we have ſeen above, that a true oil may be obtained from ſpirit of wine by treating it with acids.

But again, if we attend to the eſſential and fundamental properties of ſpirit of wine, to its perfect miſcibility with water, to its flame, which is not accompanied with any ſoot or ſmoke, to the impoſſibility of reducing it without addition to the ſtate of coal; laſtly, to this property, that when it is inflamed we obtain nothing from it but a matter which burns, and pure water; all which properties are not ſuitable to an oil properly ſo called, we muſt acknowledge, that not oil, but pure phlogiſton, is the inflammable principle of ſpirit of wine. We have reaſon to believe, that the oil which is ſeparated from ſpirit of wine by water is extraneous to it, and is only contained in ſpirit of wine, becauſe the means employed to purify this ſpirit are inſufficient to deprive it of all oily matter; and alſo, that the oil obtained from mixtures of ſpirit of wine with acids, is evidently an artificial oil, and produced in the operation, as we may ſee at the word ETHER.

As ſpirit of wine contains a pure phlogiſton very much unfolded, and almoſt diſengaged, it acts upon the nervous ſyſtem, like all the ſubſtances which contain a very volatile and very attenuated inflammable principle. See WINE and PHLOGISTON. It is alſo very powerfully antiſeptic: hence it is very ſucceſsfully employed to preſerve from putrefaction matters ſuſceptible of it. It is uſed topically in gangrenes; and alſo for the preſervation of dead animals, or parts of animals.

See for the rectification and purification of ſpirit of wine, RECTIFICATION.

DCXLVI. SPIRIT *of* LIBAVIUS. *See* LIQUOR (SMOKING).

DCXLVII.

DCXLVII. SPIRIT *of* NITRE. Spirit of nitre and nitrous acid are two names for the ſame thing. For its properties, *ſee* ACID (NITROUS). We ſhall here explain the manner of diſtilling it, or of decompoſing nitre in order to obtain it.

Vitriolic acid, and ſeveral matters containing it, are intermediate ſubſtances employed for the ſeparation of nitrous acid from the fixed alkali with which it is united in nitre; becauſe, in general, the former of theſe two acids is ſtronger than the latter. In ſeveral ways nitrous acid may be obtained by diſtillation; which however are fundamentally the ſame, although they vary in ſome circumſtances, according to the nature of the intermediate ſubſtance employed, and the required ſtrength of the nitrous acid.

The moſt frequent method of diſtilling ſpirit of wine, eſpecially in great works, is to employ clay as an intermediate ſubſtance. As this kind of earth contains vitriolic acid, it is very proper for decompoſing nitre.

Two parts of dry and powdered clay are to be well mixed with one part of nitre. This mixture is to be put into an earthen-ware retort, placed in a reverberatory furnace. To this retort a receiver is to be fitted, which is to be well luted, and the diſtillation is to be promoted by a gradual heat, that is very gentle at firſt, and raiſed towards the end ſo much that the retort ſhall be very red-hot.

The diſtillers of aqua fortis uſe very few precautions, and accordingly their ſpirit is generally weak and impure. For, in the firſt place, they employ nitre of the firſt, or at moſt of the ſecond boiling, which contains always much common ſalt. Hence the acid which they obtain is mixed with a conſiderable quantity of ſpirit of common ſalt. It is conſequently a kind of aqua regia.

In the ſecond place they do not dry well their clay, by which means their acid is weak; although they always keep apart the moſt watery part which paſſes firſt; this they call *dephlegmating it.*

Laſtly, the lute which they uſe for joining their veſſels is only earth formed into a paſte with water, a part of which falls into the receiver, eſpecially when they unlute the veſſels, and renders the ſpirit of nitre turbid. But as almoſt all the aqua fortis which they make is for purpoſes in which the ſame accuracy is not required as in chemical operations, this aqua fortis is ſufficiently good for the uſes for which it is employed.

Diſtillers of aqua fortis do not uſe retorts, but ſtone-ware bottles, with ſhort crooked necks. The receivers are veſſels exactly of the ſame form. Two rows of theſe veſſels are diſpoſed oppoſite to each other, in an oblong furnace called *a galley*; and a wood-fire is uſed for the diſtillation. The operation laſts twelve hours.

Very good, very pure, and even very ſtrong ſpirit of nitre may be made by the method of the diſtillers of aqua fortis. For this purpoſe nitre of the third boiling muſt be employed; the veſſels muſt be carefully luted with a fat lute compoſed of dry clay, pounded, ſifted and formed into a paſte, with a ſufficient quantity of boiled linſeed oil; laſtly, the contained matter muſt be dephlegmated more than is uſual, before the luting is applied. The diſtillers attend to all theſe things, when good ſpirit of nitre is required, and a ſufficient price is given. We may obſerve that ſpirit of nitre is never ſo high colored and ſmoking, when diſtilled

diſtilled by means of clay, as when obtained by the other methods, although it may be equally ſtrong.

DCXLVIII. SPIRIT *of* NITRE (SMOKING). Two methods are uſed in chemical laboratories to obtain a very ſtrong and ſmoking ſpirit of nitre. The firſt is by means of martial vitriol, previouſly calcined till it becomes red-hot, that all the water of its cryſtallization may be expelled. Alſo, very pure nitre of the third or even fourth boiling muſt be well dried. Theſe two matters are to be pounded and carefully mixed together in equal proportions. They are then to be poured into a good earthen ware retort through a paper funnel, which paſſes into the belly of the retort, that none of the powder may adhere to the neck of it. The retort is placed in a reverberatory furnace, upon the bars of which is fixed an earthen diſh filled with ſand. To the retort a large glaſs balloon, in which is a ſmall hole, is to be fitted and luted with a fat lute. This lute is to be covered with a cloth ſoaked with another lute made of quicklime ſlaked in air, and formed into a thin paſte with whites of eggs. The whole luting apparatus is to be bound with a ſtring. Then the diſtillation is to be commenced with a very ſlow fire. The balloon will ſoon be filled with red vapors which are condenſed there, while another portion of ſpirit of nitre diſtills gradually by drops. This diſtillation is to be continued till the retort is red-hot, and no more vapor is raiſed.

When the veſſels are cooled, they are cautiouſly to be unluted, and the liquor in the balloon is to be quickly poured into a clean and dry glaſs bottle, through a glaſs funnel; which bottle ought to be quickly ſtopped with a glaſs ſtopple. This is the method of diſtilling ſmoking ſpirit of nitre uſed by Mr. Beaumé; and it is a very good one. The ſmall earthen diſh filled with ſand, on which the bottom of the retort reſts, is very uſeful to prevent the too ſudden and too unequal application of heat, which would make it certainly liable to be broken. The fat lute of clay and linſeed oil is not capable of being injured by acids, and ſtops very cloſely. But as it remains always ſoft, it requires to be held by the linen ſoaked in lute of lime and whites of eggs.

The vapors of this ſmoking ſpirit of nitre are very elaſtic, and difficultly condenſible; for which reaſon the diſtillation muſt be ſlowly conducted, and muſt be avoided in hot weather. A brick wall muſt be interpoſed betwixt the furnace and the balloon to prevent this veſſel from being too much heated, the balloon muſt be covered with wet cloths frequently renewed, and even the ſmall hole of the balloon muſt be ſometimes unſtopped to give vent to the too rarefied and too copious vapors; otherwiſe the whole apparatus would burſt with explosion.

When we perceive that the drops ſucceed each other rapidly, and that by unſtopping the ſmall hole, red vapors dart out the length of a foot or more with a hiſſing noiſe; this is a ſign that the veſſels are ready to burſt. The heat then muſt be leſſened, and the ſmall hole muſt be very frequently unſtopped, till the diſtillation be much moderated.

Laſtly, when we pour the nitrous acid into the bottle, we ought to be very careful not to ſtand in the way of a current of air, becauſe the vapors are very corroſive and noxious. For the ſame reaſon alſo, the mouth of the balloon ought to be ſtopped as ſoon as the liquor is poured out of it; for the fumes continue in it more than twelve hours.

DCXLIX.

DCXLIX. SPIRIT (GLAUBER's SMOKING) of NITRE. Glauber was the first chemist who thought of distilling nitrous and marine acids by means of pure vitriolic acid. By this method we may obtain a nitrous acid highly concentrated; and the process is more easy, quick, and convenient, than the preceding. This distillation ought to be made in the following manner.

Very pure nitre is to be put into a stone-ware or glass retort. Upon this nitre, one-third part of its weight of pure vitriolic acid, rectified, and highly concentrated, is to be poured through a glass funnel, the stalk of which ought to be long enough to go down into the belly of the retort, to prevent any of the acid from adhering to its neck. The apparatus of vessels is to be disposed in the same manner as in the preceding experiment, and the distillation is to be promoted with the same precautions; and with this difference only, that this distillation is sooner finished, and requires a less heat towards the end.

The spirit of nitre, distilled in these two latter methods, is the strongest and most smoking that can be obtained. This in Glauber's manner is a little less red and smoking than the other; although it may be as strong, and even more so than the other. The former is rendered so smoking by the phlogiston of the iron of the martial vitriol. Some chemists add some filings of iron in the distillation in Glauber's manner, to render the spirit more smoking.

We may observe, that spirit of nitre obtained by any of these methods is never absolutely pure. It is indeed free from a mixture of marine acid, when nitre perfectly purified has been employed; but we cannot prevent, especially in the distillation in Glauber's manner, some part of the vitriolic acid from rising with it. It must therefore be purified from this acid, when the operations or experiments require a perfectly pure nitrous acid. This purification is easily effected by adding some pure nitre to the acid, and distilling a second time; by which means the small portion of vitriolic acid mixed with the spirit of nitre is made to unite with the basis of the nitre, and is rendered so fixed that it cannot rise in distillation. We may easily perceive, that for this rectification of the nitrous acid much less heat is required than for the former distillations.

All the residuums of these distillations contain a vitriolated tartar, called *sal de duobus*.

The residuum of the distillation of spirit of nitre by clay contains a vitriolated tartar mixed with a large quantity of earth, and therefore not easily to be extracted. The clay is baked, hardened, and generally very red, because the clays employed for this purpose are ferruginous. This caput mortuum forms a very good cement used for pavements. It is used also, for sake of its color, to make compartments, and to vary the colors of sandy parterres. It is called the *cement of distillers of aqua fortis*.

The residuum of the distillation by vitriol contains vitriolated tartar, mixed with a pretty large quantity of the martial earth of this vitriol. Vitriolated tartar may be very easily obtained from it by lotion with water, which is afterwards to be filtrated, evaporated, and crystallized. A very red martial earth remains, which is called *colcothar*, or *sweet earth of vitriol*, after it has been sufficiently washed.

We must remark upon this subject, that as the nitrous acid is disengaged from its basis by the acid of vitriol, it ought naturally to be applied to the

martial earth of this vitriol. But as the nitrous acid adheres but weakly to iron, especially when this metal is calcined and deprived of its phlogiston, as it is in this operation, the heat that is employed is more than sufficient to disengage it, and to make it pass entirely in distillation.

Lastly, the residuum of the distillation of spirit of nitre in Glauber's manner, when no iron is mixed with it, forms a very white and very pure vitriolated tartar, which may be dissolved, filtrated, evaporated, and crystallised.

All these residuums generally contain also a little nitre, which not having been sufficiently in contact with vitriolic acid, has escaped its action, and is not decomposed.

DCL. SPIRIT (DULCIFIED) *of* NITRE. Dulcified spirit of nitre is a mixture of one part of nitrous acid with two parts of rectified spirit of wine, digested together. *(u)*

As nitrous acid acts powerfully on spirit of wine, it is rendered considerably milder by this mixture. It is used only medicinally, and is considered as aperitive, and powerfully diuretic. It is added by drops to potions and juleps, till it has given an agreeable acidity.

DCLI. SPIRITUS RECTOR. The *spiritus rector* is a very attenuated, very subtle principle, in which the smell of all odoriferous bodies peculiarly resides.

To obtain the spiritus rector from odoriferous substances, these matters are to be distilled in the cucurbit or body of an alembic placed in a water-bath, with a very gentle heat, that is, from thirty to thirty five degrees of Mr. Reaumur's thermometer, till we perceive that what rises in distillation has little or no smell.

The principle of smell in bodies is in general too subtle and too fugacious to be obtained alone and pure, by any method whatever. Accordingly it rises by means of the water contained in substances distilled in order to procure it, and is dispersed and overwhelmed in water. If the odoriferous matters from which the spiritus rector is required to be procured, were absolutely dry, and contained no other volatile principles, a little water or spirit of wine ought necessarily to be added, to furnish a kind of basis to this spirit, which would otherwise be dissipated and evaporated, so that it could not be collected.

This principle of the smell of bodies is miscible with water, with spirit of wine, and with oils. It seems however to be of different natures, according to the substances which furnish it. Its properties shew that it is in general composed of an inflammable principle, and of a saline substance, both extremely attenuated. But the spiritus rector of some substances appears to be more of a saline, and that of others more of an oily nature.

All matters, the smell of which is quick, pungent, and which do not affect the brain and nervous system, as the acrid, cruciform plants, and substances which undergo the acid fermentation, contain a spiritus rector probably more saline than oily.

Those on the contrary whose smell is sweet, nauseous, or strong, without acrimony or pungency, and which affect the head, by curing or occasioning hysterical or convulsive accidents; such are ambergrise, musk, castor, burnt

(u) The London and Edinburg Dispensatories direct that the mixture should be distilled. This operation ought to be performed with a very slow, and gradually raised fire, that explosions may be prevented.

coffee,

coffee, opium, narcotic plants, camphor, all aromatic plants, and lastly, the substances which undergo the spirituous fermentation; have, according to all appearance, a spiritus rector, which partakes of the nature of oil. For besides that the effects produced by these substances are similar to those of the vapor of charcoal, the spiritus rector of some of them is really inflammable; as, for instance, that of fraxinella, the exhalations from which form an atmosphere that may be inflamed with a lighted taper.

The spiritus rector of all aromatic plants seems particularly to be associated with their essential oils; at least, all these oils contain a good deal of it. To this principle they certainly owe their smell, and probably their volatility and thinness; for those which from age, or from not having been preserved in well closed vessels, have lost their proper smell, are at the same time much less thin and volatile, since they are no longer capable of being raised by the heat of boiling water; and besides, the plants from which the spiritus rector has been obtained, furnish little or no essential oil. *See* Oils (Essential)

The spiritus rector, even that of aromatic plants, although it be of an oily nature, is perfectly miscible with water; which can only proceed from its great tenuity, or from the saline principle which enters its composition.

DCLII. SPIRIT *of* SALT. The spirit of salt, or acid of common salt, can only be obtained by means of a sufficiently powerful intermediate substance, to disengage it from the native fixed alkali, which is the basis of common salt. Vitriolic acid is the most proper and most useful intermediate substance for the distillation of spirit of salt. It is employed, either engaged in a basis with which it has a less affinity than with that of common salt; or pure, in order to obtain Glauber's smoking spirit of salt.

Ordinary spirit of salt is distilled by the mixture of one part of common salt with two parts of dried clay, precisely in the same manner as we have described for the distillation of spirit of nitre. *See* Spirit *of* Nitre. The spirit of salt obtained by this method is white and not smoking, although it may be considerably strong, if the salt and clay have been previously well dried

We may observe, that a smoking spirit of salt cannot be obtained by means of martial vitriol, calcined till it becomes red, as is practised for the spirit of nitre. I have tried to make this distillation; and although a very violent heat was applied, but very little marine acid was procured. The true reason of this difference is, that marine acid dissolves, much more easily than nitrous acid, metallic earths deprived of their phlogiston, and adheres to them much more strongly. Hence, as soon as the marine acid is disengaged from its basis by the acid of vitriol, it applies itself to the martial earth of this vitriol, which retains it with much more strength than it is capable of retaining nitrous acid.

DCLIII. SPIRIT (GLAUBER's SMOKING) *of* SALT. To have the strongest and most smoking spirit of salt, we are obliged to employ as an intermediate the pure vitriolic acid, as Glauber has practised. But this operation, especially when we would have spirit of salt highly concentrated, is very difficult and laborious, because the vapors are much more difficultly condensible than any others. The following is the process successfully practised by Mr. Beaumé.

Common salt is put into a tubulated stone-ware or glass retort, which is to be placed in a furnace for distilling; and to this retort a balloon is to be

fitted, exactly in the ſame manner as for the diſtillation of ſmoking ſpirit of nitre. *See* SMOKING SPIRIT *of* NITRE. This apparatus is to be left till the lute has become firm; then through the tubulated opening of the retort, by means of a glaſs funnel, a quantity of rectified vitriolic acid previouſly diluted with a little water, equal to a third part of the weight of the ſalt, is to be poured at ſeveral different times, and the opening is to be cloſed each time immediately after a part of the acid has been added.

As ſoon as the vitriolic acid is added, we ſee white vapors paſſing from the retort into the receiver. Theſe are the ſmoking ſpirit of ſalt which this acid diſengages, even without fire; for which reaſon theſe firſt vapors ought to be allowed to paſs, before the fire be kindled; which ought not to be done till they are conſiderably diminiſhed, otherwiſe the diſtillation would go on too faſt at firſt, and the veſſels might be broken.

A very little fire is to be kept up in the furnace, and only as much as is neceſſary to continue the diſtillation. Laſtly, the diſtillation is to be conducted to the end with the ſame attentions which we directed for ſmoking ſpirit of nitre; and when it is finiſhed, the ſpirit of ſalt is to be collected in the ſame manner.

Betwixt this proceſs and that by which a ſmoking ſpirit of nitre is obtained in Glauber's manner, two eſſential differences may be perceived. The firſt is, that in this diſtillation the vitriolic acid is not added till the veſſels are arranged and luted; and hence a tubulated retort is neceſſary. The reaſon of this is, that vitriolic acid diſengages the acid of common ſalt without heat, and as ſoon as it touches this ſalt; and that the vapors which paſs out copiouſly from the retort, by keeping the neck conſtantly wet, render the application of the lute impoſſible. When the lute happens during the diſtillation to be deranged, it cannot be again repaired. The ſhorteſt method then is to diſcontinue the operation, and begin again.

The ſecond difference betwixt the diſtillation of ſmoking ſpirit of nitre and ſmoking ſpirit of ſalt by means of vitriolic acid, is, that water is added in the latter diſtillation, and not in the former. The reaſon of this is, that the vapors of concentrated marine acid are ſo much more difficultly condenſible than thoſe of nitrous acid equally concentrated, that if well concentrated vitriolic acid, and decrepitated common ſalt, be employed, almoſt all the marine acid would be diſſipated in vapors which would be loſt, and ſcarcely a ſenſible quantity of liquor would be obtained. *See* ACID (MARINE) *for the properties of ſpirit of ſalt, and* SALT (COMMON).

The reſiduums of the diſtillations of ſpirit of ſalt contain Glauber's ſalt. In that of the diſtillation by means of clay, this ſalt is confounded with much earth, and difficultly obtainable. But the reſiduum of the diſtillation by vitriolic acid is pure Glauber's ſalt. This ſalt appears a white ſaline maſs at the bottom of the retort. It ought to be calcined in a crucible, that any remaining acid may be expelled. It is then to be treated by ſolution, filtration, and cryſtallization.

By this diſtillation, Glauber firſt diſcovered the ſalt which he afterwards examined, and called *ſal mirabile*. This name is ſtill continued; ſo that it is now called *ſal mirabile*, *ſal mirabile Glauberi*, or *Glauber's ſalt*. *See* SALT *of* GLAUBER.

DCLIV. SPIRIT (DULCIFIED) *of* SALT.

Dulcified

Dulcified ſpirit of ſalt is made by mixing this acid with twice its weight of rectified ſpirit of wine, and digeſting this mixture during a month.

As this acid has much leſs diſpoſition than the vitriolic and nitrous acids to combine with inflammable matters, it cannot be ſo well dulcified as they can by ſpirit of wine.

Authors differ much concerning the methods of dulcification. The proportions are from two to five or ſix parts of ſpirit of wine to one part of ſpirit of ſalt. Some authors do not ſay whether the ſpirit of ſalt ought to be concentrated and ſmoking, or not; others require that a ſmoking ſpirit ſhould be employed Laſtly, ſome direct the diſtillation of the mixture, and others are contented with a ſimple digeſtion. But in whatever manner the operation is performed, the acid remains crude, and not much dulcified: hence dulcified ſpirit of ſalt is not uſed in medicine; for its virtues do not eſſentially differ from thoſe of dulcified ſpirit of nitre, which is infinitely milder.

Marine acid, although very concentrated and very ſmoking, does not produce, when mixed with ſpirit of wine, but a very inconſiderable heat and efferveſcence, and much inferior to thoſe occaſioned by vitriolic acid, and ſtill more by nitrous acid; which difference proceeds from the little action marine acid has upon the principles of ſpirit of wine.

Theſe two ſubſtances are but little altered by being mixed together: for Mr. Pott having combined a dulcified ſpirit of ſalt with an alkali, obtained a *regenerated ſea-ſalt*, which decrepitated upon hot coals, and precipitated lead and ſilver from their ſolutions in nitrous acid into corneous metals. Nevertheleſs, we are certain that a part of the marine acid contracts an union, and even an intimate union, with ſpirit of wine: for Mr. Pott relates, that having diſtilled to dryneſs the thick matter remaining after the moſt fluid and volatile part of the mixture had been ſeparated, he found a black, reſiduous coal, which cannot be obtained by diſtilling any of theſe two matters ſeparately. *See* ETHER (MARINE).

DCLV. SPIRIT *of* SULPHUR. Spirit of ſulphur is nothing elſe than vitriolic acid obtained from ſulphur by burning.

As ſulphur cannot furniſh its acid but by burning, and as it cannot burn but in open veſſels and free air, we can therefore obtain but a ſmall quantity of acid by this method.

Before the acid of ſulphur was known to be the ſame as ordinary vitriolic acid, a ſpirit of ſulphur was prepared with great expence and trouble, upon the ſuppoſition that it had peculiar properties. For this purpoſe, ſulphur was burnt in an open crucible, placed upon a ſtand in an earthen diſh filled with hot water. A large capital or glaſs-bell was ſuſpended above this diſh. The acid of the burning ſulphur meeting the vapor of the hot water, united with this water, and fell down along the ſides of the bell, or by the beak of the capital. By this method a very weak acid was procured, which was afterwards concentrated: but at preſent this operation is only performed to ſhew, that the acid contained in ſulphur is not decompoſed during combuſtion, and that it is only one and the ſame thing with vitriolic acid.

The true method of obtaining much acid of ſulphur is to burn it in cloſe veſſels

vessels by means of a small quantity of nitre, as it seems to be practised in some places. See CLYSSUS. (x)

DCLVI. SPIRIT of VENUS. This name is given by chemists to the acid of vinegar highly concentrated, obtained by distilling verdegrise, or crystals of verdegrise, or of Venus, which are nothing else than combinations of copper with acetous acid.

The operation by which spirit of Venus is obtained is very easy. Nothing more is required than to put verdegrise, or crystals of verdegrise, into a retort, one third part of which ought to remain empty, as is usual: to this retort a receiver is to be adjusted, and the distillation begun with a very gentle fire: the first portions of liquor which pass are to be set apart, as they are nothing but phlegm: the distillation is to be promoted, by gradually augmenting the fire, till the retort begins to be red-hot, and nothing escapes from it.

The acid of vinegar passes in this distillation partly in white clouds, and partly in drops. This acid is very strong; because in general acids which are combined with any body whatever, are by that means deprived of all their superabundant water. Besides, as the acid of vinegar is fixed and retained in a certain degree by copper, it may be easily dephlegmated in the beginning of the distillation.

The spirit of Venus has a very vivid pungent smell, almost as suffocating as volatile sulphureous acid. The Count de Lauraguais discovered, that if this acid be heated in a wide-mouthed pan, and fire applied to it, it will burn entirely like spirit of wine, and leave no residuum. This experiment, added to the observations made by Becher and Stahl upon the production of vinegar, shew, that spirit of wine enters as a constituent part into the composition of this acid.

(x) The greatest part of the vitriolic acid now employed is obtained by burning sulphur. The vapors of burning sulphur are the volatile, vitriolic, or sulphureous acid. These are very difficultly condensible. For which reason, very large vessels and much time are required in this operation. Some artists use leaden, and others use glass vessels. The bottom of each of these vessels is covered with a little water to assist the condensation of the vapor. Above the water is placed a small vessel capable of containing a few pounds of sulphur, to which a small portion of nitre is added by some artists, because by this addition, a larger quantity of sulphur may be burnt without access of fresh air. The vessels are to be filled with the vapor of hot water, and their sides wetted with the condensed steam: then the sulphur is to be kindled by touching it with a red-hot iron: the vapor of the burning sulphur rises slowly; and when it has risen as high as the mouth of the great vessel, this must be stopt, or very nearly stopt, that the vapor may be confined. The sulphur continues to burn till the air contained within the vessel and the nitre be no longer capable of maintaining the combustion. The vapor remains a considerable time before it be entirely condensed, notwithstanding that this condensation is facilitated by the water in the vessel, and especially by the steam of water with which the vessel was previously filled. When all the vapor of the sulphureous acid is at last condensed, the sulphur is to be again kindled, and more added if it be necessary, and the process repeated as before. When a sufficient quantity of acid is collected, it is to be taken out of the vessel; and after it has lost its *sulphureous* or volatile quality by exposure to air, it is concentrated and rectified by distillation. *See* ACID (VITRIOLIC), ACID (VOLATILE SULPHUREOUS), *and* CONCENTRATION *of* VITRIOLIC ACID.

acid. The Count de Lauraguais alſo obſerved, that ſpirit of Venus well concentrated, eaſily cryſtallizes without addition; and this obſervation has been ſince confirmed by the Marquis de Courtanvaux. *See* FERMENTATION (ACID), *and* VINEGAR.

As the laſt portions of the acid of vinegar adhere pretty ſtrongly to the copper in the verdegriſe, and to the cryſtals of Venus; and as we are obliged to give a ſtrong degree of heat to expell them, they then raiſe along with them a ſmall quantity of this metal, which gives a greeniſh color to the ſpirit of Venus: but it is eaſily freed from theſe cupreous parts by a ſecond diſtillation with a very gentle heat; and then it becomes very white.

The acid of vinegar, thus concentrated, has many other properties worthy of attention; amongſt others, thoſe of forming ether when diſtilled with ſpirit of wine. *See* ETHER (ACETOUS), *and* VINEGAR (RADICAL).

We muſt obſerve, that when verdegriſe is employed for the preparation of ſpirit of Venus, we obtain very little of this ſpirit, and that it is more oily than when it is obtained from cryſtals of verdegriſe, which furniſh nearly one half of their weight of the ſpirit.

After this diſtillation, we find in the retort the copper which had been the baſis of the cryſtals of verdegriſe. This copper is divided into very ſmall parts, which, however, are agglutinated into lumps that are very friable. Its color is blackiſh, which proceeds from a covering of coal that it has received from the oily matter of the vinegar, which is decompoſed towards the end of the diſtillation. Mr. Beaumé obſerves, that this coal is eaſily kindled by the application of fire, and burns, like tinder, upon the ſurface of the copper.

This copper, not having loſt any of its phlogiſton, may be eaſily fuſed into an ingot of red copper. We ought only to add a little black flux, to prevent or repair the calcination which may be made during its fuſion.

DCLVII. SPIRIT *of* WINE. *See* SPIRIT (ARDENT).

DCLVIII. SPIRIT *of* VINEGAR. *See* VINEGAR (DISTILLED).

DCLIX. SPIRIT *of* VITRIOL. This name is given to the firſt portions of phlegmatic vitriolic acid which paſs in the diſtillation of vitriol, or in the concentration of vitriolic acid. The name is given in general to every dilute vitriolic acid.

DCLX. SPIRIT (VOLATILE) *of* SAL AMMONIAC. The volatile ſpirit of ſal ammoniac is the volatile alkali that is the baſis of ſal ammoniac, and that has been diſengaged by means of ſome intermediate ſubſtance, which alſo has taken from it ſome of its oily principle, by means of which it was capable of a ſolid or concrete ſtate; hence this ſpirit is always liquid.

The intermediate ſubſtances which have the property of producing this alteration upon volatile alkali are ſtony and metallic calxes. If two parts of quicklime ſlaked in the air, or of minium, be mixed together with one part of ſal ammoniac, and if this mixture be diſtilled, a fluor volatile alkali will be obtained in form of a very quick and penetrating ſpirit.

Mr. Schloſſer, in his Diſſertation on the Fuſible Salt of Urine, ſays, that the volatile alkali which ſerves as a baſis to the phoſphoric acid in this ſalt is always fluor, whether it be diſengaged by fire alone, or by any intermediate ſubſtance;

ſubſtance; and that concrete volatile alkali combined with this acid can never afterwards be obtained but in a fluor ſtate; which ſhews, that the phoſphoric acid has the property of taking from volatile alkali the matter by means of which it is cryſtallizable. *See for the properties of volatile ſpirit of ſal ammoniac,* ALKALI (VOLATILE), *and* AMMONIAC (SAL).

DCLXI. STEEL. Steel, conſidered chemically, is nothing elſe than iron reduced by art to a particular ſtate, which occaſions ſome changes in its properties; but theſe properties are eſſentially the ſame as thoſe of iron; that is, iron and ſteel are not two different metals, but the ſame metal in two different ſtates: therefore all the fundamental properties of ſteel are mentioned under the article IRON. We ſhall here only deſcribe the method of making ſteel, explain the theory of that operation, and mention its differences from thoſe of iron.

Stahl, Cramer, and all good chemiſts, juſtly conſider ſteel as an improved iron, which is poſſeſſed of a larger quantity of inflammable principle, ſo neceſſary to all metals, and which really contains fewer heterogeneous, and more metallic, parts than an equal bulk of iron. We ſhall be convinced of this truth by a deſcription and explanation of the methods of converting iron into ſteel, and by examining the characteriſtic properties of ſteel.

Steel may be made by fuſion or by cementation. The firſt method is uſed to convert iron into ſteel immediately from the ore. All ores of iron are not uſed indifferently for this purpoſe, becauſe ſome of theſe, which are therefore called *ores of ſteel,* are much fitter than others to furniſh good ſteel; and the ſteel extracted from them is called *natural ſteel.*

The other method of making ſteel conſiſts in chuſing the beſt forged iron, or that which is moſt malleable, whether it be hot or cold; and in impregnating this iron with a larger portion of inflammable principle, by cementation alone, without fuſion.

To underſtand well theſe methods of making ſteel, we muſt attend to two eſſential properties of iron. The firſt is, that of all metals it is the moſt difficultly fuſible; and that therefore although in the ſmelting of its ores its fuſion be much aſſiſted by the ſulphureous parts of the ore itſelf, yet, as theſe parts are always expelled as much as is poſſible, iron never enters into ſo thin and perfect a fuſion as the other metals.

The ſecond property of iron to which we ought to attend is, that the earth of this metal is capable of combining with the inflammable principle, and of being metalliſed without fuſion.

Theſe things being premiſed, it happens, in conſequence of the former property, that, in the firſt fuſion of ores of iron, we obtain only a hard and brittle iron, both from the ſulphureous parts from which this iron is not entirely diſengaged, and from the preſence of a greater or leſs quantity of earthy matters, which are either unmetallic; or which, if they be ferruginous, have not been metalliſed, from want of immediate contact with the phlogiſton of the fuel.

We may eaſily perceive that theſe earthy parts, unmetallic or not metalliſed, cannot be entirely ſeparated from the perfect iron, becauſe the fuſion is not ſufficiently thin for that purpoſe: but in proportion as the iron is deprived of ſulphur, its fuſion becomes more and more difficult, and we are obliged to have recourſe to another expedient than fuſion to diſengage it from its earthy

parts,

parts, which in the first smelting remain intercepted betwixt the metallic parts. This expedient is the forge. The impure iron intended to be rendered malleable is to be heated red-hot, and struck by a very heavy hammer.

This percussion, that iron softened by heat sustains, presses strongly, and solders or welds together the metallic parts, which only are capable of uniting together; and obliges the unmetallic parts, which are incapable of uniting with the metal, to separate. By this operation these unmetallic parts are pressed between the parts of the iron, and driven by degrees to the surface of the metal, from which they are detached in form of dust and scales. This treatment, which is a kind of kneading of the iron, is to be repeated till it has acquired the proper degree of purity and ductility.

The operations by which steel is to be extracted from its ores are essentially the same as these employed for iron; but they differ from them in being much more exact; that an iron still purer, more filled with phlogiston, and better disengaged from its earthy parts, may be obtained.

To succeed in this intention, much smaller quantities must be fused at once than when iron is to be extracted from its ore. Pieces of the first fusion are to be put into crucibles filled and covered with charcoal, and exposed to a violent heat excited by strong bellows. These pieces are to be well fused, and kept in fusion a longer or shorter time, according to the nature of the ore; after which, they are to be forged, as iron is, but always in much smaller pieces, and till they are become perfectly ductile both when hot and when cold. Nothing then remains but to temper the steel, of which we shall presently speak.

In these operations, which are to be several times repeated, the iron that is changed into steel must evidently be much better purified, and furnished with a much greater quantity of inflammable principle, than in the smeltings and fusions of large quantities of iron. As the masses of metal are small in these operations for the procuring of steel, and as they are surrounded with a much larger proportion of charcoal, the fusion is not only more compleat, by which the separation of the earthy unmetallic parts is much promoted, but also a greater number of ferruginous parts are well metallised; and as all these parts of iron are in more intimate contact with the charcoal, which is capable of supplying them with inflammable principle, they receive the whole quantity of this principle, with which they can unite.

The same observation may be applied to the operation of the forge practised upon smaller masses; for the heterogeneous parts are much more easily and copiously pressed out of small masses than great.

This exact purification of iron, by which it is converted into steel, must evidently be attended with considerable loss, or diminution, from the separation of all its heterogeneous parts. This diminution amounts to nearly one half of the weight of the iron. This great loss does not proceed altogether from the separation of heterogeneous parts; for in all the operations used for this separation, some part of the metal is always destroyed and burnt, although all possible precautions are taken to diminish this inconvenience, by securing the melted or red-hot metal from the contact of external air as much as is possible.

Artificial steel is made without fusion from iron ready forged. The chief point to be attended to in the making of the best artificial steel, is to chuse the iron which is most perfect and most malleable, either when it is hot or cold; which quality always shews that the iron is well purified. It is first to be forged into plates or bars, rather small than large, according to the works for which it is intended; and it is then to be cemented with matters capable of giving to it much inflammable principle. The matters which compose this cement vary according to the uses of different manufactures. They are all good, provided they contain no sulphur, or vitriolic acid, which might form sulphur during the operation; because sulphur, having much affinity with iron, would certainly unite with this metal, would entirely or partly fuse it, and would, by reducing it to a mineral or pyritous state, give to it qualities very different from those which good steel ought to have.

The matters which enter into the composition of the cement for steel, are the coals of animal or vegetable substances mixed with ashes, calcined bones, and other matters of this kind. Mr. Cramer proposes the two following receipts of cements for steel, which appear to be very good.

Take one part of powder of charcoal, half a part of wood-ashes, and mix them very well together: or,

Take two parts of charcoal, moderately pulverised; one part of bones, horns, hair or skins of animals, burnt in close vessels to blackness, and powdered; half a part of wood ashes, and mix them well together.

When steel is to be made, the bars of iron are to be placed vertically in a cylindrical crucible, which ought to be three inches higher than the bars, and into which a stratum of the cement of about the thickness of a finger has been previously put and pressed down The bars ought to be about an inch distant from each other, and from the sides of the crucible. The interstices and crucible are then to be filled with cement, so that the bars shall be covered with about the thickness of two inches at least. The crucible, previously covered with a lid which fits it exactly, and which must be carefully luted with clay mixed with sand, is to be placed in a furnace where an equal fire is to be kept; so that the crucible shall be red-hot during eight or ten hours: the iron will then be found to be converted into steel, which will be so much better as the iron employed was of a better quality: it then only requires to be tempered. We may observe, that in this operation the iron suffers no diminution of weight, and no scoria appears upon its surface, as Mr. Cramer remarks. By the sole addition, therefore, of a new quantity of phlogiston, the iron acquires the quality of steel. Thus, if this iron contained some parts of martial earth which was not metallised, by the cementation they are metallised, and the iron or steel are thereby improved: but if the iron contained some earthy unmetallic parts, they are not separated by this operation, because the metal has not been fused; and as the best forged iron which is usually sold is never so well purified from these extraneous matters, as that which is converted into steel in the great works for procuring steel from the ore of iron; hence, in general, artificial steel made by cementation is not so perfect as that made by fusion.

We may observe that, in the cementation above described, the iron combines with a part of the phlogiston of the cement, without fusion; which effect proceeds from a peculiar property of the earth of iron by which it is capable of com-

combining with the inflammable principle, and of being metallifed without fufion, which is, neverthelefs, neceffary for the reduction of all other metallic earths.

The fteel which has received only the above-mentioned preparations differs from iron in its color, which is more dark and brown; in its grain, which is finer and clofer; in poffeffing a greater ductility, flexibility, and foftnefs: but the great difference of fteel from iron, which renders it more valuable for many purpofes and arts, is the extreme hardnefs it acquires by being tempered.

This operation is very fimple. It confifts in making fteel red-hot, and then in plunging it fuddenly in cold water. In an inftant all the qualities of this fteel are changed by this tempering; fo that from being very ductile and foft, it becomes fo hard and fo ftiff, that it is no longer capable of being cut by the file, but is itfelf capable of cutting or piercing very hard bodies; that it does not yeld to the hammer, but may be fooner broken in pieces like a flint, than be extended. It is fonorous, brittle, very elaftic, and capable of acquiring the moft lively and moft beautiful polifh, as we fee in finely wrought toys of fteel.

The ufe of this metal is very extenfive for numberlefs convenient and neceffary utenfils of all forts, of which without it we fhould abfolutely be deprived: but what renders its ufe ftill more general is, that we can diverfify at pleafure its hardnefs and ductility, by varying the temper. The hotter the fteel is when tempered, and the colder the water into which it is plunged, the greater hardnefs it acquires; but, at the fame time, it becomes fo much more brittle. This very hard temper is neceffary for certain tools defigned to cut very hard bodies. On the contrary, the lefs hot the fteel is when tempered, and the hotter the water is in which it is tempered, the lefs hard it becomes, and alfo the greater ductility it retains; and hence many tools may be made of it fit for cutting bodies moderately hard, which tools are lefs liable to have their points broken, or their edges notched, than if they were made of a harder fteel.

No other general rule can be given for the tempering of fteel than that we have mentioned. The proper degree of heat is always relative to the ufe to which the tools to be made of this fteel are to be applied.

Another very convenient property of fteel is, that after it has been tempered, it may be again untempered and foftened to any degree that we think proper. For which purpofe we have only to heat it more or lefs, and to let it cool flowly. By this method we may foften the hardeft-tempered fteel.

As the temper is a very effential point with regard to fteel, and that the beft is in general that which gives the greateft hardnefs, and deftroys the leaft of the ductility of the metal, various fubftances are ufed, into which fteel to be tempered is plunged. Such are fuet, oil, urine, water impregnated with foot, with fal ammoniac, or with other falts. Thefe particular methods are the bafes of many fecrets in different manufactures; their advantages cannot be afcertained without a very accurate and continued examination. Very interefting refearches remain to be made on this fubject.

Steel is ufually fold tempered, becaufe, in many manufactures of it, the cuftom is to temper it as foon as it is made, probably that the purchafers of it may be better able to judge of its quality. When this fteel is to be ufed, it

muſt be untempered, that it may be extended, filed, and receive the form intended to be given to it; after which each workman tempers it again in his manner. But we alſo find amongſt merchants Engliſh ſteel in ſmall bars, which is not tempered, and which is very good.

Well poliſhed plates of ſteel, put on a gentle fire of charcoal, acquire different colors on their ſurface, and paſs ſucceſſively through ſeveral ſhades, as they become hotter, in the following order, white, yellow, orange, purple, violet, and laſtly, blue, which diſappears and leaves a water-color, if the ſteel has been heated too much or too long. Theſe different ſhades mark the degree of heat or of annealing applied to different tools or utenſils. The moſt generally uſed ſhade is the blue, ſuch as that given to ſteel ſprings.

One of the moſt important properties of ſteel is the magnetic quality which it is capable of acquiring much better than iron. Good mariners compaſſes cannot be made without needles of ſteel.

From what we have ſaid, we may judge that ſteel is much better purified iron than any other iron, impregnated with a larger quantity of inflammable principle, and hardened by the temper. Some celebrated natural philoſophers, but who were not chemiſts, have advanced, that ſteel was only iron which ſtill retained ſomething of its mineral nature, and that its ſtate was intermediate betwixt that of caſt iron and ſoft forged iron. But this opinion is manifeſtly erroneous. They have been deceived by the hardneſs and brittleneſs of caſt iron, which are nearly as great as in ſteel. But theſe qualities proceed from a remaining part of the mineraliſing ſubſtances, which leave it a pyritous character, very different from that of true ſteel, ſince this can only be hardened by the temper, and ſince in the preparation of it all ſulphureous matter muſt be carefully avoided. The miſtake of theſe authors proceeded from their ignorance of the inflammable principle, the properties of which have been ſo well explained by the illuſtrious Stahl, and from their being led into an error by the old chemiſts, who perpetually confounded phlogiſton, or the pureſt and ſimpleſt inflammable principle of all bodies, with ſulphur, with ſulphureous matters, and with moſt other inflammable compounds.

Steel may be un-made, or reduced to the ſtate of iron, by a management ſimilar to that by which it is made, that is, by cementation. But the cement uſed for this purpoſe muſt be compoſed of ſubſtances entirely free from inflammable matter, and rather capable of abſorbing it, as calcareous earth and quicklime are. By a cementation then with theſe matters continued during eight or ten hours, ſteel is reduced to the ſtate of iron.

Stahl conſiders it as an undecided queſtion, whether ſteel be more fuſible than iron, and ſays, that the workmen cannot decide it from the violence of fire neceſſary to melt either of them. He believed with reaſon, that this queſtion might be decided by melting theſe metals in the focus of a burning ſpeculum. Mr. Macquer ſays, that by this method he found ſteel much more fuſible than iron (*y*). This greater fuſibility of ſteel can be only attributed to

(*y*) Soft forged iron can ſcarcely without addition be brought into perfect fuſion by the heat of our furnaces, till the phlogiſton of the fuel has converted it into ſteel. But ſteel is daily melted and caſt into ingots, called *caſt-ſteel*, by which it is rendered more uniform and ſimilar in all its parts, and thereby fitter for being wrought into the finer kinds of utenſils for which ſteel is employed. This caſt-ſteel, when again reduced

the greater quantity of phlogiston united with it, as phlogiston is in general the cause of the fusibility of metals. (z)

duced to the state of forged iron by cementation with absorbent earths, is the most uniform, equal, perfect iron which can be obtained.

(z) By conversion of iron into steel, this metal acquires a closer, more compact and finer-grained texture, greater hardness, elasticity, tenacity, sonorousness, and disposition to receive the magnetic property; and, as is said, a greater gravity, both absolute and relative. It is also rendered less liable to rust by exposure to air; and less liable to emit sparkles when heated. The colors or irises which steel acquires by exposure to heat, and which are marks by which workmen know when any required heat is given, are not peculiar to steel and iron, but may also be produced by the same means on all other calcinable metals. These colors proceed from a calcination gradually advancing on that part of the metals which is exposed to air. And as the particles of metals in their different degrees of calcination are probably of different sizes, so they must acquire (according to Sir Isaac Newton's theory, which shews that the colors of bodies depend on the size of their integrant parts) different reflective powers, and exhibit changes of colors.

Steel may be made by fusion, or by cementation with inflammable matters. Anciently steel is said to have been made by immersing forged iron during some time in melted crude iron. Forged iron may also be changed into steel, as Wallerius affirms, by immersion in melted scoria; or by fusion with black flux, glass-gall, or borax; or by strewing sea-salt upon heated iron, and extinguishing it in dung.

Various opinions are formed concerning the cause of the difference between iron and steel. The most general opinion attributes this difference to the presence of a larger quantity of phlogiston in the latter than in the former. Some authors, attending chiefly to the method of conversion by fusion, consider that operation only as a purification of the iron from earthy and heterogeneous particles, and steel merely as a more pure and perfect iron. Others, observing some similitude in the texture of steel to certain kinds of cast iron, and the hardness of both these, without attending to their essential differences, have imagined that the state of steel was intermediate betwixt that of cast and that of forged iron. Lastly, some metallurgists maintain that the conversion of iron into steel is effected not by absorption of phlogiston, but by expulsion of sulphureous or acid particles. To support this opinion, they observe, 1. That steel is less disposed than iron to rust; the cause of rust being, as they think, an acid contained in iron; 2. That steel emits fewer sparkles under the hammer than iron, which sparkles are found to be most frequent in iron abounding with sulphur, as in red-short iron; 3. That iron may be converted into steel by cementation with alkaline salts, capable of attracting the acid and sulphur; 4. That in the preparation of steel by fusion, the metal is rather exposed to a dissipation of its inflammable parts and burnt, than further phlogisticated; and that this operation is accordingly called by workmen *the burning of steel*.

In the preparation of steel by fusion, probably much of the earthy matters contained in the iron may be separated, and any contained acid or sulphur may be burnt or dissipated. But the conversion of steel into iron by cementation with absorbent earths, in which operation no acid or sulphur can be absorbed by the metal, shews that the difference between iron and steel does not consist in the presence of an acid or of sulphur in the iron, but in the presence of some substance in the steel, which the inflammable cementing substances can give to it, and of which absorbent earths can deprive it. This substance has been, with great probability at least, believed to be phlogiston; by the addition of which the metal acquires a new texture, together with the hardness, elasticity, and other peculiar properties of steel: we doubt not, however, that in the operations for making steel, by fusion or by cementation, any contained acid or sulphur may be expelled, and thus the metal may be meliorated, and rendered less liable to rust and to emit sparkles.

The

The affinities and medicinal virtues of steel are the same as those of iron. See Iron.

DCLXII. STONES. This name is given in general, both in chemistry and in natural history, to many bodies of very different natures. But generally hard and compact bodies of an earthy nature are called *stones*.

As many different kinds of stones as of earths may be distinguished. For the parts of every kind of earth being united and agglutinated together, are capable of forming, and actually do form stoney bodies. But as this union of the integrant parts of any earth does not really change the nature of this earth; and as it always has the same essential properties, especially when considered chemically; we refer to the word Earth for all that we have to say concerning stones. The origin, and the sensible qualities by which naturalists distinguish different kinds of stones, are treated of in *Mr. Bomare's Dictionary of Natural History*.

Several chemical preparations are also called stones, of which we shall here treat.

DCLXIII. STONE (CAUSTIC), *or* Common Caustic. *See* Caustic.

DCLXIV. STONE *of* BOLOGNIA. This stone has been much celebrated for the property it has of becoming phosphoric by calcination. It is a heavy selenitic spar. All spars of that kind, and also several other stones, have the same property. *See* Phosphoric (Stones), *and* Spars.

DCLXV. STONE (INFERNAL), *or* Lunar Caustic. *See* Caustic (Lunar).

DCLXVI. STONE (PHILOSOPHER's). This name is given by alchemists to the preparation, by which metals may be transmuted, gold and silver made, and all the wonders produced of (what they call) the *great work*. *See the articles* Metals *and* Metallisation.

DCLXVII. SUBLIMATION. Sublimation is an operation by which volatile and solid substances are collected and obtained.

This operation is founded on the same principles as distillation, and its rules are the same, as it is nothing but a dry distillation. Therefore all we have said on the article Distillation is applicable here, especially in those cases where sublimation is employed to separate volatile substances from others which are fixed or less volatile.

Sublimation is also used in other cases; for instance, to combine two volatile matters, as in the operation of the sublimates of mercury; or to collect some volatile substances; as *sedative salt*, *sulphur*, and all the preparations called *flowers*.

The apparatus for sublimation is very simple. A matrass or small alembic is generally sufficient for the sublimation of small quantities of matter. But the vessels and the method of managing the fire vary according to the nature of the matters which ought to be sublimed, and according to the form which ought to be given to the sublimate.

The beauty of some sublimates consists in their being composed of very fine, light parts; such as almost all those called flowers; as *flowers of sulphur*, and of *benjamin*,

benjamin, *sedative salt*, and others of this kind. When the matters to be sublimed are at the same time volatile, a high cucurbit, to which is adapted a capital, and even several capitals placed one upon another, are to be employed. The sublimation is performed in a sand bath, with only the precise degree of heat requisite to raise the substance which is to be sublimed; and the capitals are to be guarded as much as is possible from heat. The height of the cucurbit and of the capitals is well contrived to accomplish this intention.

When along with the dry matter which is to be collected in these sublimations a certain quantity of some liquor is raised, as happens in the sublimation of sedative salt, and in the rectification of volatile concrete alkalis, which is a kind of sublimation, a passage and a receiver for these liquors must be provided. This is conveniently done by using the ordinary capital of the alembic, furnished with a beak, and a receiver.

Some sublimates are required to be in as solid and compact masses as their natures allow. Of this number are camphor, sal ammoniac, and all the sublimates of mercury. The properest vessels for these sublimations are bottles or matrasses, which are to be sunk more or less deeply in sand, according to the volatility and gravity of the matters that are to be sublimed. In this manner of subliming, the substances having quitted the bottom of the vessel, adhere to its upper part; and as this part is low and near the fire, they there suffer a degree of heat sufficient to give them a kind of fusion. The art therefore of conducting these sublimations consists in applying such a degree of heat, or in so disposing the sand, (that is, making it cover more or less of the matrass) that the heat in the upper part of the matrass shall be sufficient to make the sublimate adhere to the glass, and to give it such a degree of fusion as is necessary to render it compact; but at the same time, this heat must not be so great as to force the sublimate through the neck of the matrass, and dissipate it. These conditions are not easily attained, especially in great works.

Many substances may be reduced into flowers and sublimed, but which require for this purpose a very great heat with the access of free air, and even the contact of coals, and therefore cannot be sublimed in close vessels. Such are most soots or flowers of metals, and even some saline substances. When these sublimates are required, the matters from which they are to be separated must be placed among burning coals in open air, and the flowers are collected in the chimney of the furnace in which the operation is performed. This process is called *sublimation in the manner of Geber*. The *tutty*, *calamine*, or *pompholix*, which are gathered in the tops of furnaces in which ores are smelted, are sublimates of this kind.

DCLXVIII. SUBLIMATE (CORROSIVE). This preparation, called also *mercury corrosive sublimate*, is a mercurial salt, in which mercury is united with the largest quantity of marine acid with which it is capable of combining intimately.

This salt is called *sublimate*, because it can only be well prepared by sublimation; and it is called *corrosive*, because it is one of the most corrosive salts or even the most corrosive of all salts with metallic bases.

Corrosive sublimate may be made by several processes, which, however, are all so contrived, that the vapors of mercury and of marine acid shall meet in the same subliming vessel.

The

The most usual method consists in mixing well nitrous mercurial salt with vitriol of iron and common salt, all well dried; and in promoting the sublimation, as we have said under the article MERCURY.

Another process consists in dissolving mercury in concentrated vitriolic acid, as when turbith mineral is made; in triturating the white saline mass remaining after this solution, previously dried, with an equal weight of dried sea-salt; and in subliming this mixture in a matrass with the heat of a sand-bath, by encreasing the fire till nothing more is sublimed. This process is given by Mr. Boulduc, in the Memoirs of the Academy for the Year 1730. Mr. Spielman observes, in his *Chemical Institutions*, that Kunckel had given it formerly, in a work called *The Chemical Laboratory*.

In this operation, the acid of the vitriolic mercurial salt quits the mercury to unite with the alkali of common salt, to which it has a greater affinity, and with which it forms a Glauber's salt, that remains at the bottom of the matrass after the sublimation; while the marine acid on one side, and the mercury on the other, being both disengaged, are reduced into vapors by the effect of heat, unite strictly together, and form the corrosive sublimate, which attaches itself to the upper part of the matrass. This sublimate consists partly of a white, semi-transparent, saline mass, and partly of shining crystals, composed of small and pointed plates.

This method of making corrosive sublimate is well-contrived, and seems preferable to the ordinary process; 1. Because the mercury, being previously dissolved by vitriolic acid, is as easily and perfectly mixed with common salt in this as in the ordinary process. 2. Because the acid of the vitriolic mercurial salt disengages powerfully and plentifully the acid of common salt; and that it is necessary, as we shall see, that the mercury should meet all the quantity of marine acid with which it is capable of uniting, to obtain the most corrosive sublimate. 3. The process of Kunckel and Mr. Boulduc is more simple than that with vitriol; the operator is less exposed to the acid vapors, the mixture from which the sublimate is separated is less voluminous, and therefore this method is justly preferred.

We think we ought to observe, upon the subject of this process, that almost all chemists, who have mentioned it since Mr. Boulduc, say, that it is made from a mixture of turbith mineral with common salt. This is an inaccuracy capable of leading readers into a mistake; for the vitriolic mercurial salt, employed by Mr. Boulduc, is very different from *turbith mineral*; it contains a large quantity of concentrated, vitriolic acid, which is very necessary in the operation; whereas turbith mineral contains very little or no vitriolic acid, when it has been well washed, according to Mr. Beaumé's experiments; and consequently if turbith mineral be employed with common salt, in the proportions directed by Mr. Boulduc, we should obtain no sublimate, or but a very small quantity of a sublimate, which would not be corrosive.

The saline sublimates of mercury may be obtained by several other processes; for instance, the vitriol of the ordinary mixture may be omitted; we might also employ crude mercury instead of the mercurial nitre, and triturate it a long time with vitriol and salt, as Lemery says, or sublime the *white precipitate* alone. But we shall say no more of these methods, because they are all inferior to those we have mentioned, when a very corrosive sublimate is required; altho' some

fome of them, as the fublimation of white precipitate, be very convenient, and may furnifh a fublimate which probably is very good, when it is intended to be afterwards converted into *fweet mercury*, or *mercurial panacea*. But we muft mention another method of making this faline fublimate of mercury, propofed alfo by Lemery, becaufe it is founded on a miftake which ought to be made known.

This method confifts in triturating crude mercury with twice its weight of common falt; and in fubliming this mixture, from which, according to Lemery, may be obtained a white fublimate, lefs corrofive indeed, as he acknowledges, than the ordinary fublimate, but which, neverthelefs, is corrofive.

What Lemery fays upon this fubject is certainly true; but a modern author infers from thence, that mercury decompofes common falt, that marine alkali has not a ftronger affinity than mercury with marine acid, and that this experiment contradicts eftablifhed affinities. But none of all thefe confequences is juftly deducible. We explain this kind of paradox in the following manner.

For this purpofe we muft previoufly know, 1. That common falt, even when cryftallized very regularly, is not a pure, homogeneous falt; but that it is intimately mixed with another falt, compofed of marine acid, neutralized by a calcareous earth. 2. That the acid of this marine falt, with calcareous bafis, efcapes merely by the action of fire, and without any other intermediate fubftance than a little moifture. 3. That when mercury is fublimed with ordinary common falt, that is, common falt which has not been purified from the mixture of this falt with calcareous bafis, it combines with the acid of this latter falt, and not with that of the true common falt, and forms a mercurial fublimate. The proof of this is, that if, as Mr. Beaumé has done, common falt be diffolved in water, and if into this folution fome of the lixivium of foda be poured, till no more earth be precipitated, in which operation the falt with earthy bafis is evidently decompofed, and is changed into a falt with bafis of fixed alkali; and if the pure falt remaining in the liquor be afterwards cryftallized, and mixed with mercury, and the fublimation be attempted, not a particle of faline fublimate of mercury will be obtained. This experiment has been verified moft fcrupuloufly by Mr. Beaumé. Mercury fingly cannot decompofe common falt, therefore none of the confequences inferred from the inaccurate experiment of Lemery are juftly deducible. We might draw other confequences not very favourable to the chemift alluded to, but we abftain from them on account of his perfonal merit, and that we may not imitate the harfh and fatyrical criticifms which difhonour his writings.

The fublimates compofed of mercury and marine acid, in which the metallic fubftance has had an opportunity of combining with all the acid with which it was capable of uniting, are evidently combinations of a precife and determinate proportion of thefe two fubftances. Accordingly corrofive fublimate, when well made, that is, as corrofive as it can be, being fublimed a fecond time with new marine acid, does not unite with a larger quantity of acid, nor become more corrofive. But we do not yet feem to have determined precifely the proportion of marine acid, relatively to that of mercury, in the moft corrofive fublimate. According to Lemery, fixteen ounces of mercury produce nineteen ounces of corrofive fublimate; and, according to Takenius, in the great works in Holland, where this preparation is made, 280 pounds of crude mercury furnifh 360

 pounds

pounds of ſublimate; which would ſeem to prove, that the quantity of marine acid is greater in the ſublimate mentioned by Takenius than in that by Lemery. But as more of the mercury may be diſſipated when the quantity operated upon is but ſmall, than when it is large, we can aſcertain nothing from comparing together the reſults of theſe two authors. However, we ſee that the quantity of mercury is much larger than that of the acid, ſince even in the ſublimate of Takenius, the quantity of mercury was more than three times the quantity of acid; which deſerves to be remarked, as we ſhall ſee when we mention the principal properties of corroſive ſublimate.

The ſpecific gravity of this mercurial ſalt has not been hitherto determined, but it is evidently very conſiderable. It is very cryſtallizable, either by the uſual method for cryſtallizing ſalts, or by ſublimation, and the form of its cryſtals is the ſame in both caſes. It is not deliqueſcent, is difficultly wetted by water, and, in this reſpect, is ſimilar to arſenic. It is one of the ſalts which are very little ſoluble in water. According to the experiments of Mr. Spielman, an ounce of diſtilled water can diſſolve only thirty grains of it, with the aſſiſtance of a heat of fifty degrees of Fahrenheit's thermometer, which correſponds nearly to the tenth degree above the freezing point of Mr. Reaumur's thermometer; that is, that with this heat water can diſſolve only a nineteenth part of its weight of corroſive ſublimate.

All theſe properties of corroſive ſublimate are naturally deducible from the large quantity of mercury which enters its compoſition; it perfectly reſembles in this reſpect all the neutral ſalts, which contain a matter that is not ſaline, intimately joined to the ſaline principle. But this circumſtance is very remarkable, that corroſive ſublimate has at the ſame time very contrary properties, by which it alſo reſembles thoſe neutral ſalts in which the acid is but little connected and imperfectly ſaturated with their baſis. Theſe properties are, 1. Its corroſive quality, which renders it one of the moſt violent and active poiſons; and, 2. Its capacity of receiving a much larger proportion of mercury, which unites intimately with its acid, ſaturates it entirely, and even ſo completely, that this ſalt, from being very corroſive, is rendered, by this new addition of mercury, a ſweet ſublimate, almoſt inſipid, almoſt unſoluble in water, and which has nothing in common with a neutral ſalt but external appearance.

Theſe latter properties of corroſive ſublimate do not allow us to doubt that marine acid, although already united in this ſalt with a large quantity of mercury, and even very intimately, is yet very far from being ſaturated. Accordingly this acid is, at the ſame time, in two ſtates in ſome meaſure contrary. Several of the properties of corroſive ſublimate ſeem to ſhew that its acid is ſaturated as compleatly as the acid of the moſt perfect neutral ſalts; while other properties indicate that it is far from being compleatly ſaturated.

To form a juſt idea of this ſingular ſtate of marine acid in corroſive ſublimate, we muſt firſt of all obſerve, that we ſhould judge very erroneouſly of the ſtate of the acid of a neutral ſalt, if we conſidered the properties of this ſalt as depending only on its acid. We have elſewhere obſerved, and we ſhall prove it further in this article, that bodies which are not ſaline, being united to acids in neutral ſalts, have their peculiar action as well as theſe acids; and that the properties of theſe ſalts are always the reſult of the combined properties of their acids and of their baſes.

In the second place, we ought to recollect the distinction we have made under the article SATURATION, into *relative saturation*, and *absolute saturation*, which are two things very different; because, in fact, it happens in many combinations, that a principle is in a relative, perfect saturation, with regard to another; that is, that it is united with all the quantity of this second principle which it can dissolve, although it be very far from being in a state of absolute saturation; that is, from having so exhausted all its action upon this second principle, that no more remains to be exercised upon any other substance: For, if this were not so, we could not make any decomposition by an intermediate substance. Thus in bodies compounded of two principles, such as, for instance, neutral salts, one of their principles, and not the other, may be relatively saturated. Also one of the two principles, or both, may be in a perfect, relative saturation, although one or both be far from absolute saturation.

These things being premised, if we reflect on the properties of corrosive sublimate, we shall easily perceive, 1. That the marine acid cannot be united with so large a quantity of mercury as it is in this salt, without being considerably approximated to a state of absolute saturation; hence corrosive sublimate does not redden blue colors, has no acid taste, does not attract the moisture of the air, is very crystallizable, and not very soluble in water; in a word, that it is nearly in the same state as several neutral salts, as vitriolated tartar and others, the acids of which are generally considered as being well saturated.

Secondly, We shall easily discover also, that although the acid of corrosive sublimate approaches as much to absolute saturation as the above-mentioned properties indicate, it is not nearly in a state of relative saturation with regard to the mercury; since we know that it is capable of uniting again with a much larger quantity of mercury than is in corrosive sublimate, as is shewn by the transformation of corrosive sublimate into sweet mercury; and we shall naturally conclude from these facts, that marine acid is capable of uniting with so large a quantity of mercury, that it cannot be entirely saturated with that substance, without exhausting almost all the action it is capable of, and approaching nearly to the state of absolute saturation. Accordingly we see, that the properties of this acid become insensible, and are almost annihilated in sweet mercury.

Thirdly, in reasoning still from principles above-mentioned, and in applying them to corrosive sublimate, it will evidently appear, that although the acid of this salt is not nearly saturated with mercury, as we have observed, the mercury is nevertheless in a state of relative saturation, with regard to the acid; since, according to Mr. Rouelle's experiment, this salt cannot by any means receive a larger quantity of acid. But if, on the other side, we attend to the quantity of mercury in corrosive sublimate, it will appear very probable, that although this mercury be saturated with acid as much as it can be, and that in this respect it be in a state of perfect relative saturation, yet it is very far from having exhausted upon this acid all the tendency it has to combination in general, and from being in a state of perfect, absolute saturation. In fact, on one side, the aggregation of the mercury is broken in corrosive sublimate, and consequently all its integrant parts are capable of exerting their general tendency to combination: but, on the other side, these parts of mercury are united but to a very small quantity of acid, and probably much of their tendency to union remains

therefore unsatisfied; and we may reasonably conjecture, that from this condition, or state of the mercury in corrosive sublimate, proceeds the causticity of that saline matter.

This notion will undoubtedly appear very bold to those who are accustomed to consider the causticity of saline matters as an effect only of the concentration and imperfect saturation of their saline principles.

But we repeat it, that we should judge very erroneously of the properties of any compound body, if we were to attribute them to one of its principles only. On the contrary, all the phenomena of chemistry shew, that all the constituent parts of any compound contribute more or less to all the properties of this compound. All the parts of matter are active, by the general tendency which they have to mutual combination. Nothing is purely passive in nature; and if certain substances seem to us to be inactive and inert, it is because their parts, having exhausted all their tendency and activity one upon another, by their union, are in a seeming rest, which we call saturation, and do really become inactive with regard to many other bodies: but when by some cause this union is broken, and its parts become disengaged, their essential activity then appears again in all its force, they resume all their tendency to combination, they are in a violent state, till they find some substance with which they may unite, and satisfy this tendency. This violent state, this *nisus*, are the same thing as causticity, or rather this latter quality is an effect of the former qualities rendered sensible by their exertion upon animated bodies. Accordingly, all matter in nature, however inactive and passive it may seem, is capable of becoming, by the separation of its primary integrant molecules, an agent or solvent, and a very powerful corrosive.

We conceive then, that in corrosive sublimate the aggregation of the mercury being broken, its primary integrant molecules are, on one side, in this violent state, in this tendency to union above-mentioned; and, on the other side, that as this tendency to union is only capable of being satisfied partly, and imperfectly, by the marine acid, much of it remains unsatisfied, which gives a proportionable degree of causticity to these molecules; so that the mercury itself of the corrosive sublimate is corrosive, and probably much more so than even the marine acid.

However strange and singular this opinion may appear, we shall find, by reflecting on the nature of corrosive sublimate, that no other cause of its causticity can be conceived. In fact, we must allow that this salt is much more caustic than pure marine acid. For we are certain that a gros [72 grains] of this acid, or more, diluted in water, might be swallowed without the least inconvenience; whereas half the quantity of corrosive sublimate, diluted in the same or a much larger quantity of water, would infallibly poison. If then we suppose that the causticity of this salt is nothing else than the causticity of the marine acid contained in it, how can we conceive that this acid, which, very far from being disengaged, and from possessing all its acidity in corrosive sublimate, is, on the contrary, united with more than thrice its weight of mercury, and is neutralised so as to form a very crystallizable salt, not deliquescent, and not very soluble in water, which does not change to red the blue colors of vegetables, and gives no mark of acidity, can be infinitely more corrosive than the same acid when free and disengaged? We might as well say, that vitriolic acid is more

more corrosive in vitriolated tartar than when pure. The causticity then of corrosive sublimate must be chiefly attributed to the mercury, which is the predominant and least saturated part of that saline substance. The mercury in corrosive sublimate appears to be nearly in a similar state as the earthy principle in fixed alkalis; that is to say, its aggregation is destroyed, at least in great measure, and its quantity is very large in proportion to that of the saline principle. Accordingly, corrosive sublimate, instead of changing the blue colors of vegetables to red, as acids do, changes them to green, as if it were an alkali, according to the observations of Mr Rouelle; and in the same manner as alkalis seem to owe their causticity to the proportion and peculiar state of their earth, so also does the causticity of corrosive sublimate proceed from the quantity and disposition of its mercury. This causticity then is rather of an alkaline than of an acid kind.

An objection might be made here, that if the causticity of corrosive sublimate depended on the mercury, it ought to be encreased by encreasing the proportion of the mercury; whereas we know, that the addition of more mercury has a contrary effect, as we find from the instance of sweet mercury.

The answer to this objection is not difficult. Although the causticity of corrosive sublimate depends more on its mercury than on its acid, we cannot doubt that this acid also contributes to produce this effect, according to the general rule, that all the principles of bodies conduce more or less to their properties: but the acid of sublimate is indeed nearly in the state of absolute saturation, although it is not quite in that state; and however neutralised it may seem, it is yet capable of a certain degree of action: but when it is totally saturated with mercury, it is then also completely in a state of absolute saturation; because this acid is capable of uniting with so much mercury, that when it is combined with this metallic substance, its relative saturation and its absolute saturation are almost the same thing. We need not then be surprized, that in this respect the causticity of the sublimate is considerably diminished; but, besides, when the quantity of mercury much exceeds what ought to be contained in corrosive sublimate, we may easily perceive that the parts of the mercury, being pressed nearer the parts of the acid, are also more and more united together, and approach more nearly to the state of aggregation; in which state mercury cannot have any causticity. *See for the properties, chemical and medicinal, of corrosive sublimate, the articles* Acid (Marine), *and* Mercury.

DCLXIX. SUBLIMATE (SWEET). *See* Mercury (Sweet).

DCLXX. SUBLIMATE (RED). If a solution of mercury in nitrous acid be evaporated and dried, and then exposed to a strong heat in a matrass, the nitrous acid will be separated from the mercury in great measure, and will be dissipated in red vapors; the saline mass remaining in the matrass acquires at first a yellow color, which afterwards changes to an orange color, and lastly to a red. This is called *red precipitate*. But by exposing this red matter to greater heat, it is sublimed; while its color is preserved. It is then called *red sublimate*. This sublimate is not used.

DCLXXI. SUGAR. Sugar is a crystallizable essential salt, of a sweet agreeable taste, contained, more or less plentifully, in many kinds of vegetables;

vegetables; but in moſt of them in ſo ſmall a quantity, or confounded with ſo much extraneous matter, that it cannot be obtained from them with profit.

The plant which contains the greateſt quantity of this eſſential ſalt is a kind of reed, which grows in hot climates, called *ſugar-cane*.

The method uſed for the extraction of ſugar from the cane is the ſame as is employed for the extraction of any eſſential ſalt from the juices of plants, with this difference, that as ſugar and liquors containing it are very fermentable, this ſalt is not obtained by a regular cryſtallization, but by a much ſpeedier coagulation.

After having entirely expreſſed the juice from the ſugar-canes, it is boiled in caldrons at different times with lime-water and lixivium of aſhes, both to clarify it, and to evaporate it ſo much, that when it cools, moſt of it coagulates or confuſedly cryſtallizes. This coagulated matter is to be ſeparated from the remaining liquor, which is called *melaſſes*. From this liquor, by fermentation and diſtillation, an ardent ſpirit is obtained, called *rum*. The ſolid ſubſtance, or ſugar, is mixed with much mucilaginous extractive matter, which renders it ſoft and red. To purify, or, as it is called, to *refine* it further, it muſt be rediſſolved in pure water, and its heterogeneous parts muſt be ſeparated by boiling with quicklime and lixivium of aſhes, to which is added a certain quantity of ox's blood, for a more perfect clarification and purification. Laſtly, the ſugar, when refined, is put into earthen conical veſſels open at both ends, the ſmaller of which is turned downwards. The ſugar is covered with ſome earth moiſtened with water. This water filtrates through the ſugar, diſſolves the mucilage or ſlime which ſtill adheres to the ſugar, and flows out at the opening in the lower point of the conical veſſel. In this manner is obtained this pleaſant and uſeful ſalt. To whiten and purify it perfectly many clarifications are required; the cauſe of which is chiefly a ſlimy matter, like honey, that adheres to it.

This eſſential ſalt is ſoluble in water, like all other ſalts, and even is one of thoſe ſalts that is ſoluble in the ſmalleſt quantity of water.

It is cryſtallizable; and its cryſtals, when ſlowly and regularly formed, are beautiful and tranſparent, called *ſugar-candy*. This ſalt conſiſts of an acid united with a large quantity of a very attenuated and mucilaginous earth, and with a certain quantity of ſweet and not volatile oil, which is in a ſtate perfectly ſaponaceous, that is, entirely ſoluble in water by means of the acid.

Sugar, when diſtilled, yields a phlegm, an oily empyreumatic acid, a ſmall portion of colored empyreumatic oil, and leaves a conſiderable quantity of reſiduous coal.

This ſalt is very ſuſceptible of the ſpiritous fermentation, when it is diluted in a ſufficient quantity of water; and, like all the other ſubſtances capable of that fermentation, it is very nutritive to animals.

The nutritive and fermentative parts of vegetables have not been ſufficiently examined, to enable us to determine, whether they be perfectly of a ſaccharine nature. We know, however, that they furniſh by analyſis the ſame principles, and nearly in the ſame proportion; that they all have a ſweet, agreeable, and generally ſaccharine taſte; that every vegetable or animal ſubſtance that is ſaccharine is alſo nutritive and fermentative; and, laſtly, that genuine ſugar may be obtained from moſt of them.

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Mr. Margraaf has obtained ſugar from the roots of ſeveral plants, as from carrots, parſnips, white and red beets. Some of theſe roots, as, for example, the white beet, furniſhed a very conſiderable quantity of ſugar. He obtained about half an ounce of ſugar from half a pound of the dried root. This able chemiſt, conſidering that ſugar is ſoluble in ſpirit of wine, and that the mucilaginous parts of plants are not ſoluble in that fluid, eaſily obtained a pure ſugar by digeſting the dried roots in that ſpirit, and by evaporating the liquor. Afterwards, hoping to find a cheaper method, that his diſcovery might be uſeful, he attempted ſucceſsfully to obtain ſugar by the ordinary proceſs very little varied. He could not indeed obtain a very pure ſugar without repeating very frequently the ſolutions, clarifications, and other operations, as may be ſeen in his Memoir, or in the eighth Diſſertation of his *Opuſcules Chemiques*. But at laſt he did ſucceed; and we have reaſon to hope, that by improving the proceſs, much ſugar may be obtained from other vegetables, as from green peas, cabbage, green farinaceous grains; from ſeveral trees, as the ſycamore, and the birch trees, ſome of which have more of a ſaccharine taſte than ſeveral of the plants from which Mr. Margraaf extracted ſugar.

The chief, and perhaps the only difficulty to be ſurmounted in this extraction of ſugar proceeds from the viſcid matters, which are ſo mixed and blended with the ſaccharine ſubſtance of plants, that they prevent its cryſtallization. The ſaccharine and mucilaginous parts might be ſeparated from each other by means of a menſtruum, which could diſſolve the ſugar and not the ſlimy ſubſtance, or which could diſſolve the latter and not the former. To diſcover ſuch a menſtruum ſeems to be the proper object of inquiry for thoſe who would proſecute this ſubject.

DCLXXII. S U G A R *of* L E A D. *See* SALT *of* LEAD.

DCLXXIII. S U G A R *of* M I L K. *See* MILK.

DCLXXIV. S U L P H U R. No word has been ſo much uſed by chemiſts, and at the ſame time ſo much abuſed, as *ſulphur*. By this the ancient chemiſts denoted all inflammable ſubſtances of whatever nature they might be. Sulphur, according to them, is one of the principles of bodies. They ſpoke continually of the ſulphurs of metals, of the ſulphurs of plants, of the ſulphurs of animals: oils, ardent ſpirits, reſins, bitumens, were all ſulphurs. In every thing they found a ſulphur. Even now, alchemiſts and others who have only confuſed ideas of chemiſtry, from reading old chemical books, talk inceſſantly and deciſively of ſulphurs.

To Beccher, and ſtill more to the illuſtrious Stahl, we owe the ſimple, clear, and preciſe ideas which we now have of the ſeveral kinds of inflammable ſubſtances, formerly confounded under the general name of ſulphur. By the ſagacious diſtinction they have made between the pure and ſimple inflammable principle, and the more compounded bodies which contain it, and owe their inflammability to it, we acquire a knowledge of the true theory of ſulphur and of all inflammable ſubſtances.

Since Stahl has unfolded this ſublime theory, we know that the inflammable principle is identical, always alike, and the ſame in every body; that this principle by its combination with different ſubſtances produces all the inflammable matters which we know. Oils, fats, reſins, bitumens, ardent ſpirits, coals, metals, ſulphur properly ſo called, or common ſulphur, are ſo many

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compounds, all which have the common property of burning, becaufe they all contain the principle of inflammability, but which differ in other refpects, becaufe this principle is united to different fubftances, and in different proportions.

Stahl has eftablifhed thefe important truths, chiefly by examining, by decompofing, and by re-compofing common fulphur, and by demonftrating from the moft fatisfactory experiments, that this fulphur confifts of vitriolic acid united with the pureft and fimpleft inflammable principle. We fhall relate as fhortly as we can the refults of his refearches upon this fubject.

Nature probably forms, and combines daily, mineral fulphur within the earth. This fubftance is abundantly diffufed in many places, efpecially where metallic minerals exift. Sulphur almoft pure, called *native fulphur*, is found in volcanos and in grottos, where it is fublimed in form of tranfparent cryftals. But the greateft quantity of fulphur which exifts naturally is combined with metals in ores and efpecially in pyrites. As fulphur is fufible and volatile, it is procured from thefe minerals by diftillation and fublimation. *See* SMELTING *of* ORES.

Sulphur, fuch as it is in commerce and in arts, is of a pale yellow or citron color, of a difagreeable and peculiar fmell, which is rendered more fenfible when the fulphur is heated or rubbed. By rubbing, fulphur is electrifed. Its fpecific gravity is much greater than that of water, and lefs than that of earths and ftones. It is brittle and pulverable; altho' it may alfo be eafily foftened, as we fhall afterwards obferve.

Sulphur feems to be incapable of receiving any alteration from air or from water, feparately or conjointly, nor even from fire in clofe veffels. Sulphur, expofed to heat in a fubliming veffel, is melted with a very gentle heat, and then is fublimed, and adheres to the capital, forming fmall very fine needle-like cryftals, called *flowers of fulphur*. This fublimed fulphur is effentially the fame as that which has been only melted: and it may be thus fublimed many times without alteration. If fulphur, which has been expofed to no more heat than fufficient to melt it, be cooled very gradually, it cryftallizes in form of many needles croffing each other. Some of thefe pointed cryftals may alfo be obferved in the interior parts of the lumps of fulphur which have been melted and caft into cylindrical moulds, as they are commonly fold; becaufe the center of thefe cylindrical rolls is more flowly cooled than the furface. Sulphur alfo gives this needle-like form to cinnabar, to antimony, and to many other minerals containing it.

Sulphur is inflamed and burnt by expofure to fire and to air. But the phenomena which it exhibits are different according to the manner of its combuftion. When it is very hot and burns quickly, its flame is ardent and capable of kindling inflammable bodies, but is always blueifh, not very luminous, and not accompanied with any foot or fmoke, but with an acid vapor of a penetrating and fuffocating fmell. This vapor, confined by means of a glafs bell, and received into the vapor of water, introduced for that purpofe into the fame bell, is called *fpirit of fulphur*, which we fhall afterwards fhew is the vitriolic acid, that is at firft volatile and fulphureous, from the fmall quantity of inflammable principle that it ftill retains, but which afterwards becomes pure vitriolic acid.

If, on the contrary, sulphur is burnt in open air but very slowly, its flame is so little luminous, that it can be perceived only in the dark, like a small bluish glimmering light; and so little ardent, that it cannot kindle the most inflammable substances. Mr. Beaumé proves this truth by a very fine and curious experiment, in which he burns all the sulphur that is contained in gun-powder without kindling the powder. When this experiment is made, a tile must be equally heated and to a certain degree, that is, a little more than is requisite for the success of the experiment. Upon this tile, thus heated, some grains of gun-powder are thrown, to discover the degree of heat; and if the heat be too great, the powder detonates, from time to time, as is usual. More powder is thrown on the tile, till this be so much cooled, that the powder does not fulminate, but only emits a white smoke. If the tile and powder be carried in this state to a dark place, the vapor, which seemed to be a white smoke, will then appear to be a true flame, but very bluish and faint; which will continue till all the sulphur of the powder be consumed, if the tile remains sufficiently hot for that purpose.

We may easily perceive, that when the sulphur burns thus weakly and slowly, a part of its inflammable principle is dissipated without inflammation, and that consequently the acid which is disengaged by that combustion, ought to be more volatile, penetrating, and sulphureous, than it is when the inflammation is more rapid. Hence, when we would obtain much volatile sulphureous acid by burning sulphur, as for the whitening of stuffs by the vapor of sulphur, it must be burnt very slowly, as Stahl has well remarked.

As nothing remains after the burning of sulphur, unless some extraneous body happens to be mixed with it; and as, during this combustion, nothing is perceptible but two matters, one of which is destroyed by the inflammation, and another which has the properties of the vitriolic acid; we may conclude, that sulphur is composed of an inflammable matter, and of vitriolic acid. But the examination of the other properties of this substance will render our knowledge of its nature and its principles more complete and accurate.

Sulphur heated so much as to burn, and thrown while melted and burning into water, is very quickly fixed or rendered solid, but in this experiment it acquires a considerable degree of softness, which indeed only lasts a certain time; after which the sulphur recovers its natural consistence and brittleness.

Pure acids seem to have no action upon sulphur, especially in the humid way. But Mr. Beaumé has observed that if concentrated vitriolic acid be poured upon sulphur, and heated to a certain degree, this sulphur will liquefy and appear in the water like an oil; and when it is cooled, it will have a green color; which seems to shew some action of the acid upon the sulphur. But this sulphur is not in any other respect changed.

Alkalis fixed and volatile, and even calcareous earths, dissolve sulphur, render it more or less soluble in water, and form with it compounds called *livers of sulphur*. The sulphur may be separated and precipitated, by means of an acid, from these substances; in which case, it appears as before, only much divided.

This experiment shews that sulphur is not decomposed by uniting with alkalis. Nevertheless the strong fetid smell of liver of sulphur, and the facility

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cility of decomposing sulphur while it is thus united with an alkali, shew that, in this combination, the connexion of its parts are weaker than when it is uncombined. *See* LIVER *of* SULPHUR.

Sulphur detonates with nitre, from its inflammable principle, and is then decomposed by the combustion of this principle. But in this detonation we perceive only the two principles of sulphur above-mentioned. Its phlogiston, together with that of the nitrous acid, maintains the flame of this detonation, and the acid of the sulphur is afterwards found to be combined with the alkali of the nitre, with which it forms a vitriolated tartar, called *sal polychrest of Glaser*. This is completely proved in the experiment of the *clyssus of sulphur*. *See* CLYSSUS.

Sulphur unites easily with all metallic matters, excepting gold, platina, and zinc; at least we have not found the means of uniting it with these, directly, and without some intermediate substance. The degrees of affinity with which sulphur combines with those metals to which it may be readily united, are different; for it not only unites more easily and abundantly with some than with others, but it also quits those with which it has a less affinity, to unite with others to which it has a stronger affinity.

The affinities of sulphur according to Mr. Geoffroy's table are, fixed alkali, iron, copper, lead, silver, regulus of antimony, mercury, and gold; and according to Mr. Gellert's table, they are, iron, copper, tin, lead, silver, bismuth, regulus of antimony, mercury, arsenic, and cobalt: gold and zinc are marked in this table as being incapable of uniting with sulphur.

The compounds formed by sulphur with different metals are different; but all of them possess a metallic lustre, without any ductility: these combinations of sulphur and of metals are very frequently found in a natural state. Almost all the metals which we dig from the earth are naturally found combined with sulphur, forming most of the ores and metallic minerals.

The properties of the combinations of sulphur with metallic matters have been little examined, because these combinations are not of any use; but, on the contrary, when they are found, they must be decomposed, that the metals may be obtained separately from the sulphur. Nevertheless, we know not only that metals have different degrees of affinity with sulphur; in consequence of which property, sulphur may be and actually is, in many metallurgical operations, separated from some metals by means of others, to which it is more disposed to unite; but we also know that sulphur facilitates the fusion of hard and difficultly fusible metals, such as copper and iron; and that, on the contrary, it renders the soft and fusible metals, as tin and lead, less easily fusible. These singular effects seem to proceed from the difference of the affinity of sulphur to the several metals.

Sulphur may be separated from metallic matters by several methods. First, as sulphur is volatile, and as these metallic matters are fixed, or at least less volatile than sulphur, the mere action of fire is sufficient to separate sulphur from most metals. As this method is simple, and not expensive, it is generally employed to separate sulphur from ores; which effect is produced by the *torrefaction* or *roasting* of these ores. We must, however, except the ore of mercury, or native cinnabar, and also the combinations of arsenic with sulphur, which cannot be decomposed without an intermediate substance, from the great volatility of mercury and of arsenic: although perhaps it would not be impossible

poſſible to ſeparate the ſulphur from theſe compounds, without an intermediate ſubſtance, by a heat carefully applied, long continued, and with acceſs of air.

Secondly, ſeveral combinations of ſulphur with metals may be decompoſed by means of acids, which diſſolve the metallic matter, without attacking the ſulphur. But in ſeveral of theſe compounds, the ſulphur defends the metal from the action of the acids; and this ſeparation by acids does frequently not ſucceed, or ſucceeds only imperfectly. Crude antimony is one of the ſulphurated metallic ſubſtances from which ſulphur may moſt eaſily be ſeparated by means of aqua regia. This menſtruum ſeizes readily the regulus of antimony contained in mineral antimony, and ſeparates from it the ſulphur, which then appears in form of a white powder.

Laſtly, we may, as we have already ſaid, ſeparate ſeveral metals from ſulphur by means of other metals, to which the ſulphur has a greater affinity. This ſeparation is practiſed in ſeveral operations, as in the *dry parting*, the *purification of gold by antimony*, the *decompoſition of cinnabar*, of *orpiment*, and of *crude antimony*. *See the articles* ESSAY *of* ORES; ORES; PYRITES; SMELTING *of* ORES; *and all the articles of the ſeveral metals and ſemi-metals:*

Oils and oily matters, of whatever nature, are all capable of acting upon ſulphur, and of diſſolving it. Several ſolutions of ſulphur in eſſential oils are uſed in pharmacy, which have been named from the oils employed; as *terebinthinated balſam of ſulphur*, and *aniſated balſam of ſulphur*; and other ſolutions have been made of ſulphur in expreſſed ſweet oils, as that in the oil of nuts, called *Rulland's balſam of ſulphur*.

Sulphur cannot be diſſolved in oils, according to Mr. Beaumé, without a heat ſufficient to melt it. A larger quantity of ſulphur is kept diſſolved in the oil while hot than when cold; and accordingly when oil has been ſaturated with ſulphur by means of heat, a part of the ſulphur ſeparates from it when it cools, in the ſame manner as many ſalts kept diſſolved in hot water are cryſtallized when the water becomes cold. The analogy betwixt the ſalts and ſulphur in theſe inſtances is alſo obſervable in this reſpect, that when the oil in which the ſulphur is diſſolved is very gradually cooled, the ſulphur cryſtallizes regularly, as ſalts do in ſimilar circumſtances.

Sulphur is not decompoſed by the union which it contracts with oils, when no more heat is applied than is neceſſary for the ſolution. For the ſulphur, when ſeparated from the oil, is found to be poſſeſſed of all its properties. It appears, however, that the connexion of its principles is in ſome meaſure altered by this combination; at leaſt, if we may judge from the color and ſmell of the balſams of ſulphur which are different from thoſe of the ſulphur, or of the oil.

But when the balſams of ſulphur are diſtilled with a heat capable of entirely decompoſing them, the ſulphur itſelf is then alſo decompoſed. For according to an experiment made by Homberg, and ſome other chemiſts, the ſame principles are obtained by this diſtillation continued till the matter in the retort be dry, as are obtained from a combination of pure vitriolic acid with oils. Theſe principles are, firſt, a portion of oil, when the oil of which the diſtilled balſam is compoſed was an eſſential oil; then ſome volatile ſulphureous acid, which is at firſt watery, and afterwards becomes ſtronger; along with this acid more oil

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rises, which becomes more and more thick towards the end of the distillation; and lastly, when the retort has been red-hot, nothing remains but a fixed coal.

From the above-mentioned products we find, that the sulphur and part of the oil are decomposed in this distillation. The vitriolic or sulphureous acid certainly proceeds from the sulphur: for no quantity of that acid can be obtained from any kind of oil, nor from any pure vegetable or animal oily matter. The water contained in this sulphureous acid is evidently a part of the water which is a principle of the oil: for the vitriolic acid of the sulphur being in a state perfectly concentrated and dry, as shall be afterwards shewn, could not otherwise contain so much water as it does in this operation. Lastly, the coal which remains after the operation is a portion of the earth that is a principle of the oil, intimately united with some of the inflammable principle either of the oil or of the sulphur, or most probably of both.

In this mutual decomposition of sulphur and oil, the concentrated acid of the sulphur seems to attack the watery principle of the oil, while its phlogiston, which by this new union loses much of its adhesive power, is partly disengaged, and confounded with the phlogiston of the oil. Thus the sulphur is changed into volatile sulphureous acid. And probably also a certain quantity of inflammable principle is disengaged in this experiment, and is dissipated in vapors. Such appear to be the phlogistic vapors, which, kindling at once, produce the terrible explosions that sometimes happen when the combinations of oil and of sulphur are carelesly heated. Hoffman relates a singular instance of an explosion of this kind, which happened in a laboratory, where balsam of sulphur had been left in a matrass upon the fire.

Spirit of wine does not act sensibly upon sulphur, unless these two substances be applied to each other in the state of vapor, as the Count de Lauraguais discovered. Many combinations, now believed to be impossible, might be effected by employing the most powerful means in chemistry; namely, an extreme division and separation of integrant parts, as the Count de Lauraguais has done in the abovementioned fine experiment. By this means, chiefly, we may arrive at great discoveries. From the above-mentioned properties of sulphur we learn, that this substance is composed of vitriolic acid and phlogiston. Stahl demonstrated this important truth so clearly and compleatly, as to shew the true state, and even the proportion of the principles of sulphur, not only from its analysis, but also by its artificial composition, of which we shall now speak.

The process by which this chemist made sulphur exactly similar to native sulphur, consists in mixing and melting together in a crucible equal parts of fixed alkali and of vitriolated tartar, to which is added a quantity of powdered charcoal equal to a fourth part of the weight of the salts. The matter is to be stirred with an iron rod, that the charcoal may be well mixed with the salts; the crucible is to be covered; and a pretty strong heat is to be suddenly applied, and continued during a very short time. The crucible is then to be removed from the fire, and the melted matter is to be poured upon a stone previously greased. This matter, which sparkles when it is poured, is coagulated by cold, and becomes a brittle mass, of a deeper red color than ordinary liver of sulphur; but it has the smell, the solubility, the deliquescency,

deliquescency, and all the other properties of liver of sulphur. By dissolving it in water, and by adding any acid to the solution, an artificial sulphur will be precipitated, which being collected and dried, is found not to differ from natural sulphur.

The color of this dry liver of sulphur is redder than that of the ordinary preparation of that name; and when dissolved in water, its solution its of a deep green color, in which respect also it differs from the ordinary liver of sulphur. These differences proceed from some foreign matter united with the liver of artificial sulphur; and this foreign matter is a part of the charcoal employed in the process for making the sulphur. For the whole quantity of charcoal added not being converted into sulphur in this process, some part of it is dissolved by the liver of sulphur, as soon as this is formed; charcoal being soluble in liver of sulphur, as the younger Mr. Rouelle has shewn.

We should be much mistaken if we believed, that the sulphur obtained in this operation existed ready formed in any of the substances employed, and that it is only extracted from these. Glauber had, before Stahl, performed this operation, by employing his *sal. mirabile* instead of vitriolated tartar; but from his ignorance of the true theory, he fell into this mistaken opinion. Boyle also, having procured sulphur by distilling to dryness a mixture of vitriolic acid and oil of turpentine, did not believe that he had produced this sulphur, but only that he had separated it from the substances employed. On the contrary, we know certainly from many proofs, that not a particle of sulphur exists in vitriolic acid, nor in neutral vitriolic salts with basis of fixed alkali, nor in very pure alkalis, nor in any oil, nor in any vegetable coal; and consequently the sulphur obtained in these operations is a new product, resulting from the union of the vitriolic acid with the inflammable principle of the vegetable coal, as Stahl has advanced.

The fixed alkali mixed with the vitriolated tartar in this process is not absolutely necessary; for sulphur may be produced merely from any vitriolic salt with any inflammable matter, made red-hot together: but the alkali is useful in this process, by facilitating the fusion of the vitriolated tartar, and by preventing the dissipation and combustion of most of the sulphur, as soon as it is formed. This alkali unites with this sulphur, and forms a liver, in which the sulphur is less disposed to burn, and be dissipated, than when it is not engaged with any fixed and incombustible body.

Although, rigorously speaking, the vitriolic acid itself, when disengaged, and treated properly with any combustible body, can always produce sulphur; nevertheless, in this operation, an acid engaged in some basis to which it adheres strongly ought always to be employed; such is the acid in vitriolated tartar, in Glauber's salt, and even in almost all neutral vitriolic salts with earthy and metallic bases; because vitriolic acid cannot contract with the inflammable principle the intimate union which is requisite for the production of true sulphur, excepting it be deprived of all the water that is not necessary to its saline essence; that is to say, in its highest degree of concentration, and even in a dry state. Besides, if a red heat be not absolutely necessary to effect this combination, as the sulphur formed in the solution of some metallic matters by vitriolic acid shews,

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vertheless very useful. But when a disengaged vitriolic acid is employed; as, for instance, when a mixture of this acid with an oil is distilled; the greatest part of the acid is converted into volatile sulphureous acid, while any moisture remains in the mixture, and the sulphur is not produced till towards the end of the operation, when the matter in the retort is dry; and then the concentrated remaining portion of vitriolic acid, uniting with the phlogiston of the earthy coal of the oil, forms the sulphur.

Hence, sulphur may be more copiously and quickly made by applying to a coal vitriolic acid engaged in some basis, which renders it so fixed that it may, by fire, be deprived of all superfluous water, and even be made red-hot, than by employing this acid in any other manner. Accordingly Stahl's process is the best. These considerations on the best method of making sulphur are of little value, because natural sulphur is plentiful and cheap. But the discovery that sulphur can be thus made, and the theory which Stahl has given concerning this subject, are very important. For from thence we not only learn the nature of sulphur, of which we had an imperfect, and even false, idea; but, what is much more valuable, we may thence draw a number of very important and very general inferences, the chief of which we shall now mention.

First, vitriolic acid and the inflammable principle cannot form sulphur by combining together, unless they both be deprived of all moisture, and be perfectly dry. Hence no inflammable body which contains in its composition water, such as oils and ardent spirits, can form with this acid, sulphur, but only a volatile sulphureous acid, till these inflammable matters be decomposed, and reduced to a state of coal, which is one of the dry combinations of the inflammable principle.

Secondly, the inflammable principle of all combustible bodies is always capable of forming sulphur with the vitriolic acid, provided it be, or can be made, dry. Thus ardent spirits, oils, and oily matters; or rather the coals of all these substances, and all combustible metals, do always form sulphur when treated properly with vitriolic acid; and whatever the nature of the combustible body be which transfers the phlogiston to the acid, the sulphur resulting from it is always the same, and always perfectly similar to natural sulphur. Hence an important proposition is inferred, that only one inflammable principle exists, which is always the same, whether it resides in resins, in bitumens, in oils and fat, in coals, or in metals. For if the inflammable principle of all these combustible bodies was not the same principle, these bodies might form different sulphurs with vitriolic acid, which we find from experience they cannot do.

Thirdly, vitriolic acid always quits any body with which it happens to be combined, when it can unite with the inflammable principle of any other body, and with this principle forms sulphur when it is properly applied. Hence, this acid has a greater affinity with the inflammable principle than with any other substance; and hence we may discover, by means of phlogiston, the vitriolic acid, with whatever substances it may be combined; and reciprocally we may, by means of vitriolic acid, discover the inflammable principle in all bodies in which it exists in a combustible state.

Fourthly, the principles and properties of sulphur being known, we may deduce from these properties a more accurate knowledge of the particular nature of

of the inflammable principle, by comparing the differences between sulphur, volatile sulphureous acid, and pure vitriolic acid. From this comparison we find that the smell and color of sulphur, its volatility, its constant dryness, its unsolubility in water, which properties do not belong to vitriolic acid, are produced by the inflammable principle, that possesses all these qualities in itself, or that is, at least, capable of communicating them to the compounds in the combination of which it enters. *See the Article* PHLOGISTON.

Fifthly, we have reason to believe that the inflammable principle possesses eminently the abovementioned properties; for we know that the quantity of it in sulphur is much less than the quantity of the vitriolic acid. Stahl has made a fine experiment to discover nearly the proportion of the two principles of sulphur. This experiment consists in putting a quantity of powdered liver of sulphur upon an earthen-ware plate, and placing this plate upon a fire so gentle that the liver of sulphur shall not be melted, nor even so softened that it can run into lumps. This powder must be stirred, and the fire must be encreased towards the end, till no smell be perceived. The remaining matter is to be dissolved in water, and by crystallization a very pure vitriolated tartar is formed.

In this operation, the inflammable principle of the sulphur is gradually dissipated without any sensible combustion, and its acid combines, or remains combined, with the alkali of the liver of sulphur. But we must observe, that to render this experiment exact, and to draw from it accurate conclusions, the following conditions are required: 1st, we must know precisely the quantity of sulphur contained in the liver of sulphur employed; 2dly, the liver ought to contain rather too much than too little fixed alkali, that there may be certainly enough of it to saturate all the acid of the sulphur; lastly, no part of the sulphureous acid must escape during this decomposition; and therefore no smell of this acid, but only that of the liver of sulphur, which is very different, ought to be perceived. To prevent this dissipation of volatile acid, we must proceed very slowly; and the operation accordingly requires a long time. Mr. Brandt, who has carefully repeated it, found from the quantity of vitriolated tartar obtained by this method, that, in sulphur, the proportion of inflammable principle is to that of the vitriolic acid as three to fifty; that is, that the sulphur contains only one-sixteenth of its weight of inflammable principle.

Such is the state of our actual knowledge concerning the nature and principles of sulphur, which Stahl has rendered very compleat and accurate. We find that sulphur is a peculiar combination of the purest inflammable principle with vitriolic acid; that not a particle of oil is contained in it; that it is therefore very different from bitumens, with which it has been long confounded; that, still more improperly, the name of sulphur has been given to all other inflammable bodies, which are entirely different from it; that we ought therefore to confine the name of sulphur to the compound formed of pure vitriolic acid and pure phlogiston, unless we would apply it, as the ancient chemists have done, to the inflammable principle itself, which they called the *principal sulphur*; but in this case we ought to give another name to mineral sulphur.

Let us remark, nevertheless, on the subject of the name *sulphur*, that as other acids besides the vitriolic can also contract an intimate union, and form compounds with pure phlogiston, this name may be generally applied to all

compounds

compounds of pure acid and phlogiston, which may be distinguished from each other by adding the name of the acid; as *vitriolic sulphur*, *nitrous sulphur*, and *marine sulphur*, if any such sulphur does exist: but let us also remark upon this subject, that we can give this name of *sulphur* to those compounds only which do not contain any oil; this condition being essential to the sulphureous combination; and consequently, that we cannot admit of *acetous sulphur*, of *tartareous sulphur*, or of others of this nature containing vegetable acids, which cannot ever form a truly sulphureous combination, on account of the oil which enters into their composition as an essential principle. *See the articles* Acid (Vitriolic), Acid (Volatile Sulphureous), Detonation *of* Nitre, Liver *of* Sulphur, *and* Phlogiston.

The uses of sulphur are considerably extensive in chemistry, in medicine, and in arts. The liver of sulphur is employed in chemistry for several solutions, which may be seen at the article Liver *of* Sulphur. Sulphur is also useful for several fusions, precipitations, and separations of metals and minerals, as we have already mentioned. Lastly, as sulphur contains a very large quantity of vitriolic acid, a method has been found, and is now practised, of extracting from it this acid, by burning sulphur in close vessels with the addition of some nitre, and by an operation similar to that of the clyssus. *See* Clyssus.

Sulphur is employed in medicine, both internally and externally, for asthmatic diseases of the breast, and for several diseases of the skin of the nature of the itch. The internal preparations of sulphur are, flowers of sulphur, washed sulphur, magistery of sulphur, tablets, balsams, livers of sulphur, and others, in some of which this substance is not altered, but only purified and divided, and in others, is combined and associated with other substances; without reckoning the sulphureous combinations of antimony and of mercury.

Some physicians and chemists, considering that sulphur is unsoluble in water, and capable of resisting the action of most menstruums, have advanced that it can produce no effect when taken internally, single and unaltered: but this assertion seems to be without foundation; for we are certain that the sweat and perspiration of those who take sulphur internally have a smell evidently sulphureous. Besides, sulphur is much more soluble than is generally believed. It is attacked by all oily and saponaceous substances, and consequently by almost all animal liquors.

We cannot easily form a very distinct and clear idea of the manner in which sulphur acts internally upon our bodies; but from observations made upon its effects, it appears to be dividing, stimulating, and somewhat heating: it principally acts upon the perspirable parts of the body, the chief of which are the skin and lungs; and from this property, it is particularly useful in some diseases of these parts.

Sulphur is also a powerful repellent, as appears from its curing several kinds of itch merely by external application in form of ointments and pomatums.

Several mineral waters, which are drank, or used as baths, for some diseases, owe their good qualities to sulphur contained in them. Such are the waters of Cauterets, of Mont D'or, of Aix-la-Chapelle, and of Saint-Amant. Accordingly, these waters are employed in several diseases of the breast and of the skin.

ſkin. Laſtly, ſulphur combined with other ſubſtances may contribute to their medicinal powers. *See the articles* BALSAM *of* SULPHUR, CINNABAR, ETHIOPS MINERAL, MINERAL WATERS, LIVER *of* SULPHUR, KERMES MINERAL.

Sulphur is alſo uſed in ſeveral arts. By means of it fine impreſſions of engraved ſtones are taken. Matches are formed of it; and its utility as an ingredient in the preparation of gun-powder and fire-works is well known. Laſtly, it is uſed for whitening wool, ſilk, and many other matters expoſed to its vapor during its combuſtion, the colors and redneſs of which could not be deſtroyed by any other ſubſtance, but are quickly chaced by this acid vapor.

DCLXXV. SULPHUR (GOLDEN) *of* ANTIMONY. Golden ſulphur of antimony is a mixture of ſulphur and regulus of antimony, of an orange color, which is obtained by diſſolving the ſcoria of regulus of antimony, and by precipitating this ſolution by means of an acid.

We may ſee at the article REGULUS *of* ANTIMONY, that this ſcoria is a liver of ſulphur, containing a certain quantity of the reguline part of antimony. When therefore this antimoniated liver of ſulphur is diſſolved in water, and when any acid is added to this ſolution, the acid ſeizes upon the alkali of the liver of ſulphur, by means of which the ſulphureous and reguline parts of the antimony were kept ſuſpended in the water, and at once precipitates both theſe.

Although this precipitate be compoſed of ſulphur and regulus of antimony, as crude antimony alſo is, its properties are nevertheleſs very different from thoſe of this mineral. The precipitate has no metallic color or appearance, and is beſides poſſeſſed of a powerful emetic quality, which the antimony has not. Theſe differences proceed from the ſulphur of the precipitate not being united with the reguline part in the ſame manner, nor ſo intimately, as in crude antimony. In the golden ſulphur, the reguline part is only *mixed* with the ſulphur, and is in a great meaſure diſengaged and uncombined; whereas in crude antimony, it is intimately connected and united with the ſulphur.

Golden ſulphur has ſome reſemblance to kermes mineral: but it differs eſſentially in ſome circumſtances, namely, that a ſmall portion of fixed alkali remains united with the kermes when well prepared, that is, not too much waſhed, and that the proportion of ſulphur is greater in kermes than in the golden ſulphur. To be convinced of theſe differences, we need only to attend to the circumſtances which accompany the precipitation of theſe two ſubſtances. Kermes is precipitated ſpontaneouſly without addition of any acid, and merely by the cooling of the ſolution of the antimoniated liver of ſulphur which contains it: it is therefore compoſed of the reguline part, but eſpecially of the ſuperabundant quantity of ſulphur, which the alkali cannot keep diſſolved, but by means of a heat almoſt equal to that of boiling water: whereas the ſolutions of antimoniated liver of ſulphur, not only that of kermes itſelf, but alſo that of the ſcoria of the regulus of antimony which has depoſited its kermes by cooling, contain no more ſulphur than the alkali can keep diſſolved without heat, which quantity is therefore leſs than in the kermes. Beſides, the acid neceſſary for the precipitation of the golden ſulphur ſeizes all the

alkali; whereas a little of it always adheres to the kermes during its precipitation.

The golden ſulphur of antimony was much employed when preparations of antimony were firſt introduced into medicine, but is now pretty much neglected; and juſtly, becauſe the kermes and emetic tartar produce the ſame effects more gently and more uniformly. *See* ANTIMONY *and* KERMES (MINERAL).

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DCLXXVI. TALK. *See* Mica.

DCLXXVII. TAR. *See* Pitch.

DCLXXVIII. TARTAR. Tartar is a concrete, oily, vegetable acid, which is depofited and is cryftallized in liquors that have undergone the fpirituous fermentation. It is a kind of effential falt of wine.

Probably wines of all kinds depofite a greater or lefs quantity of tartar; but the wine of grapes is one of thofe which furnifh the moft of it, and the tartar of this wine is almoft the only one that is employed or known.

All wines of grapes do not furnifh an equal quantity of tartar. Some of them depofite it abundantly, and others but a fmall quantity only. Sometimes a longer and fometimes a fhorter time is required for the depofition of tartar. Generally a long time is required, and alfo an infenfible kind of fermentation, which continues in the wine a long time after the figns of the fenfible fpirituous fermentation have ceafed. *See* Wine.

The tartar is depofited on the fides of the cafks containing wine. On thefe a hard cruft is formed, which becomes more and more thick; and as a portion of the fine dregs of the wine adheres to this cruft, the tartar of white wine is of a greyifh-white color, and is called *white tartar*; and that of red wine has a red color, and is called *red tartar*.

Tartar, when feparated from the cafks on which it is formed, is mixed with much heterogeneous matter, from which it is purified for the purpofes of medicine and of chemiftry. This purification of tartar is performed at Montpellier, and confifts (as we find from a Memoir of M. Fizes, Profeffor of Medicine at Montpellier, printed amongft the Memoirs of the Academy for the year 1725) in boiling tartar in pure water, in filtrating this water, and in allowing the faline matter to depofite by cold. By this firft operation, the groffer impurities which adhere but flightly to the tartar are feparated: but the

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crystals obtained by this operation are still red, and charged with an oily matter extraneous to the tartar.

From this extraneous matter the tartar is purified by boiling it in water in which clay is diffused. By a second filtration and crystallization, very pure and white crystals of tartar are obtained; but they are small and ill-shaped, from the quickness of their formation.

This crystallization is partly performed by evaporation, and partly by cold. The part which crystallizes by evaporation forms a saline crust upon the surface of the liquor, called *cream of tartar*; and the part which crystallizes by cold forms small irregular crystals, called *crystals of tartar*; but the name of cream of tartar has prevailed over the latter; so that it is at present applied also to crystals of tartar, and signifies in general purified tartar.

Cream of tartar has a taste sensibly acid; it reddens the blue colors of vegetables; it may be saturated by uniting with any of those substances which are capable of forming with acids neutral salts; and it may be afterwards separated from these substances, and may recover its former appearance. Accordingly, we are certain that this saline matter is an acid. Its property by which it is concrete and crystallizable, it receives from a portion of earth and oil, with which it is intimately combined, and which approximate it to the nature of neutral salts, especially in what concerns the crystallizable quality and the solubility of these salts.

Tartar, although acid, is not very soluble in water; it is even much less soluble than most of the perfectly neutral salts. According to Mr. Spielman's experiment, an ounce of distilled water can dissolve only three grains of cream of tartar, with the heat of fifty degrees of Fahrenheit's thermometer, which is equivalent to the tenth degree of Mr. Reaumur's. By help of a boiling heat, water dissolves much more tartar; but this tartar crystallizes very quickly when the water ceases to boil. The oily part of the tartar seems to be the chief cause of its difficult solubility in water.

Tartar is in a great measure decomposed and totally changed by the action of fire. If cream of tartar be distilled in a retort with a naked fire, a little phlegm will first rise with a gentle heat. When the fire is gradually encreased, which must be done very cautiously, on account of the prodigious quantity of air that is disengaged during this distillation, an acid arises in form of white vapors, which are accompanied with an oil, at first thin, but afterwards more and more colored and empyreumatic. In the retort there remains a coal, strongly alkaline, equal in weight to two-thirds of the tartar employed.

The acid obtained in this distillation is indeed oily, and therefore retains the character of a vegetable acid; but it is very different from the tartar itself. It is no longer crystallizable; it is only an oily empyreumatic acid, similar to what is obtained from all other vegetables by distillation in a naked fire. These differences must be attributed to the portion of oil and of earth, which are separated from this acid by distillation. As to the residuum of coal, the fixed alkali, which it contains ready formed, is remarkable, considering that here there is no incineration in open fire, which is generally necessary for the production of alkali from almost all other vegetables. The cause of this difference probably is, that the acid of tartar is almost entirely changed into fixed alkali, is more disposed to be alkalised than any other vegetable acid, whether this

disposition

disposition proceed from the quantity of earth and oil which are intimately mixed with it, or from some change produced upon it by fermentation. Mr. Spielman thinks, with much probability, that acids are changed into alkalis by the substraction of a part of their aqueous principle: and the nature and proportion of the constituent parts of tartar appear to be very proper to favor this substraction of the watery principle by the action of fire. This subject is still obscure, and would require a more profound examination.

DCLXXIX. TARTAR EMETIC, *or* STIBIATED TARTAR. Thus is named the compound formed of the acid of tartar combined with the metallic part of antimony, when this is half deprived of its phlogiston. It is the best and most used of all the emetic preparations of antimony, because the metallic part of this mineral, which gives the emetic quality, is in a saline state, and is perfectly soluble in water.

This preparation has been justly substituted for the golden sulphur, for the regulus, for the liver and glass of antimony, and for the powder of Algaroth. It is infinitely preferable to these preparations for the reasons mentioned; but unfortunately, the method of preparing this important remedy has not been fixed and determined. If in fact we consult the several dispensatories, we shall find very different processes directed: the cream of tartar is employed by all, but some of them require that it should be boiled with the liver of antimony, others with the glass of antimony, and lastly, some with both these preparations. The proportion also of the ingredients, the length of time of boiling, the method of crystallizing and drying the salt after it has been boiled, are different in different dispensatories. In whatever manner cream of tartar is treated with the abovementioned preparations of antimony, we always obtain an emetic tartar much preferable to the ancient emetic preparations of antimony. But we are also certain that the emetic tartars obtained by these several processes are sometimes more and sometimes less emetic; which difference is certainly a great inconvenience for so important a medicinal preparation as this is.

Probably this diversity has been occasioned by persons not considering, or not knowing, that the emetic quality of this preparation proceeds from the metallic earth being dissolved by the acid of tartar, and forming with it a kind of soluble tartar, a true neutral salt, no less capable of a very exact saturation than the vegetable salt, the salt of Saignette, and all the other soluble tartars. For this saturation being a fixed point, and easily to be found, would probably have been universally prescribed, as is done for all other neutral salts, if it had been well known to have occurred in this instance. But as it is now sufficiently ascertained, we may hope that all the faculties of medicine will adopt it, that there may be hereafter only one kind of emetic tartar, always equally strong. Upon this subject we shall add some observations.

First, although regulus of antimony be essentially emetic, it nevertheless produces less effect than the liver or the glass of antimony, because it is less soluble. These two preparations, which are only the metallic earth of antimony deprived of a part of phlogiston necessary to the reguline state, are for that reason more easily soluble by acids than the regulus, and are consequently more emetic. But the glass is still more emetic than the liver, because it has less phlogiston; and it accordingly seems to be the most emetic,

and most soluble in acids, of all the preparations [illegible] neral.

Secondly, the end proposed in making emetic tartar, [illegible] emetic preparation of antimony, in which the metallic earth is [illegible] acid, and is soluble in water by means of that acid, and thus is [illegible] the inconveniences of the ancient antimonial emetics, the glass [illegible], &c. The principal inconvenience of these emetics is, that their [illegible] very uncertain. Sometimes these effects are not sufficiently strong, [illegible] more frequently too violent. These differences of the same medicin[illegible]aration, given in the same doses, shew that the circumstances on whi[illegible] action depends are variable. They cannot act internally, till they are [illegible]d: they can only be dissolved by the acid or other liquors of the body that are capable of attracting them: But the quantity and strength of these dissolving liquors in the body are very variable, according to the different constitutions and states of the alimentary canal. Besides, the greater or less division of these antimonial preparations favors more or less their solution in the body. We need not therefore wonder that their emetic effects should be so variable and uncertain.

These inconveniences are avoided by giving a saline quality to antimonial emetics, by uniting them with the acid of tartar. They then become entirely soluble in water by means of this acid; and the whole quantity of them which is administered produces constant and uniform effects: hence emetic tartar is preferable to all other antimonials that are not in a saline state. But this preparation also must be more or less emetic, according to the quantity of regulus or metallic earth which it contains. Accordingly, Mr. Geoffroy found by examination of several emetic tartars, that an ounce of the weakest of these contained from thirty to ninety grains of regulus, that an ounce of moderate strength contained about 108 grains, and that an ounce of the strongest kind contained 15[illegible] grains of regulus. The detail of his experiments may be seen in the Memoirs of the Academy for the year 1734.

These differences of strength must proceed from the different methods employed to prepare the emetic tartars, and from the more or less perfect saturation of the acid of tartar.

Mr. Beaumé affirms from experiment, that this acid may be easily saturated with the reguline part of antimony: and as the glass of antimony is the most emetic and [illegible]st soluble of all the antimonial preparations made by fire, we ought to prefer [illegible] to all others in the preparation of a perfectly neutral antimonial soluble tartar. For this purpose, we must mix together equal parts of cream of tartar and of porphyrised glass of antimony, or rather a larger quantity of the latter ingredient. This mixture is to be thrown gradually into boiling water; and the boiling must be continued gently, till there is no longer any effervescence, and till the cream of tartar be entirely saturated. The liquor is to be filtrated; and upon the filter we may observe a certain quantity of sulphureous matter, together with some undissolved part of the glass of antimony. When the filtrated liquor is cooled, fine crystals will be formed in it, which are a soluble tartar perfectly saturated with glass of antimony. The crystals of this salt have the form of triangular pyramids (*a*). They are transparent while they are

(*a*) The author probably means pyramids, the basis of each of which is a triangle: for every pyramid must evidently have, at least, four solid angles.

moist,

moiſt; but by expoſure to a dry air, they loſe a part of the water of their cryſtallization, and become opake and white.

As the perfect ſaturation of acids requires conſtantly a determinate quantity of any ſubſtance which they can diſſolve, we ſhould be certain, by ſaturating compleatly cream of tartar with glaſs of antimony, that the emetic tartar thus prepared would conſtantly contain the ſame proportion of emetic antimonial parts. The cryſtallizing and draining of neutral ſalts in general, is a good method for obtaining them in their moſt perfect ſtate: accordingly this ſalt ought to be firſt cryſtallized; but as by expoſure to the action of air it is apt to loſe ſome of the water of its cryſtallization, it ought, immediately after it has cryſtallized, to be well dried; and then it would remain unchanged. I have frequently adminiſtered emetic tartar thus prepared, and I have always obſerved, that it very well produces an emetic effect when taken from a grain to two and a half, or three, according to the conſtitution of the patients.

Authors who have given receipts for the preparation of emetic tartar, have differed, as we have obſerved, not only as to the kinds and proportions of the antimonial preparations which they direct to be boiled with cream of tartar, but alſo as to the duration of the boiling. Some of them require that the boiling ſhould laſt twelve hours, and others only a few inſtants, believing with Hoffman, that this ſalt is ſuſceptible of decompoſition and of loſing its emetic quality by a long continued boiling. Mr. Beaumé has determined this matter by well-conducted experiments, which ſhew that emetic tartar, like other metallic ſalts, is capable of being decompoſed by other metals to which its acid has a ſtronger affinity than the metallic baſis, and that iron particularly is capable of producing this effect upon emetic tartar; ſo that if it be boiled a long time in an iron veſſel, it is actually decompoſed, and the liquor is gradually changed into a tartariſed tincture of Mars. But Mr. Beaumé alſo found that emetic tartar may be boiled during any length of time in veſſels made of ſilver or of glaſs, without being decompoſed.

The reſults of theſe experiments of Mr. Beaumé are, 1. That any veſſels ought not to be employed in the preparation of emetic tartar; that eſpecially iron, and even copper, ought to be avoided, for this latter metal is found alſo to act a little upon emetic tartar; and that veſſels of ſilver or of glaſs ought to be uſed. 2. That as the intention of the operation is to ſaturate perfectly the cream of tartar, the boiling muſt be continued till this ſaturation be effected, which requires a long time when the glaſs of antimony is groſly pounded, but a much ſhorter time when it is well porphyriſed, as Mr. Beaumé practiſes.

We muſt acknowledge that emetic tartar, prepared by thus ſaturating completely the acid of tartar with glaſs of antimony, muſt be infinitely more uniform in its effects, than what is obtained by any of the other proceſſes hitherto practiſed. Nevertheleſs, when we reflect on the nature of the glaſs of antimony, we cannot affirm that this emetic preparation, notwithſtanding its perfect ſaturation, muſt always be of equal ſtrength. Glaſs of antimony is made by fuſing the grey calx of antimony, calcined to a certain degree. We know alſo, that if it be too little calcined, we ſhall obtain an opake matter, that reſembles the liver more than the glaſs; but that if it be too much calcined, it cannot be vitrified, nor even fuſed, by the moſt intenſe heat. But

between

between the degree of calcination which is sufficient to give an opake fused matter, and the degree when it begins to be unfusible, there are many intermediate degrees of calcination, all of which are sufficient to produce glasses of antimony; but these glasses differ in degree of transparency, intensity of color, and fusibility, according as the calcination has been more or less compleat. We cannot doubt that different glasses of antimony must be more or less emetic, and that perhaps different quantities of these glasses are required for the perfect saturation of the acid of tartar. Besides, we are not only ignorant of the degree of calcination which renders the glass most emetic; but also, if we did know it, we have no certain method of attaining it precisely.

Hence, we are not certain that emetic tartar, prepared by saturating tartar with glass of antimony, has always an uniform and constant emetic power. These considerations have determined me to search, among the several preparations of antimony, for one which should have the same advantages that glass of antimony has, of being convertible into a neutral salt by means of tartar, without the inconveniences of its uncertain degrees of emetic strength; and I have found that the *powder of Algaroth*, or *mercury of life*, is capable of answering these intentions.

This preparation, which was formerly employed as an emetic, has been justly rejected with the other antimonials that have not a saline quality, because it has the same inconveniencies as these have. It occasioned accidents so terrible, that some physicians have affirmed, that it ought with more propriety to be called the *mercury of death* than the *mercury of life*. But these fatal effects do not prevent the possibility of rendering it a good remedy by a proper preparation; in the same manner as glass of antimony, which given singly produced much mischief, has saved many lives since it was converted by its union with tartar into a most efficacious remedy.

Two causes concur in rendering the powder of Algaroth a violent and uncertain remedy. The first is common to it with glass of antimony, and with all the other antimonial preparations that are not saline; and is, its want of solubility in water, for the reasons that we have assigned. The second cause of the violent and uncertain effects of powder of Algaroth is, that a certain quantity of marine acid remains united with it, and communicates to it a certain degree of caustic quality. But both these causes of the bad effects of this preparation may be easily and certainly removed. For, by washing it with a little fixed alkali, all the acid may be separated. And I have found from experiments, that the powder thus washed is altogether soluble by cream of tartar, and of being thereby convertible into a soluble emetic tartar, perfectly neutral; for which purpose, nothing more is required than to boil it, and saturate it with cream of tartar, and to treat it in the manner above directed for the preparation of emetic tartar with glass of antimony. We may easily perceive that powder of Algaroth thus prepared is a calx of antimony constantly of the same degree of emetic strength. It is emetic, because the regulus of antimony first dissolved by marine acid, and afterwards separated from that acid, retains the quantity of phlogiston that is necessary to give an emetic quality to the calx of antimony: but the quantity of phlogiston which it retains, and therefore its emetic power, must always be the same: for the marine acid of

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the corrosive sublimate, which afterwards becomes the acid of the butter of antimony, is always the same in quantity, and in its degree of concentration and of activity: consequently the calx of antimony separated from it must always contain an equal quantity of phlogiston; and is therefore much preferable to glass of antimony, which contains sometimes more and sometimes less phlogiston.

By substituting therefore powder of Algaroth to glass of antimony, and by treating it in the manner above-mentioned, we may obtain the most uniform and certain emetic tartar that can be prepared: physicians, who must be sensible of the advantage of such a remedy, need not be anxious concerning its degree of strength. If it were once known, they would have occasion only to attend to the sensibility or irritability of the constitutions of their patients. *See the articles* ANTIMONY, POWDER *of* ALGAROTH, GLASS *of* ANTIMONY, *and also all the other preparations of antimony.*

DCLXXX. TARTAR (VITRIOLATED). Vitriolated tartar is a neutral salt composed of vitriolic acid saturated with the fixed alkali of tartar, or with any other very pure vegetable fixed alkali.

This salt is prepared by pouring vitriolic acid into a solution of vegetable alkali, till no more effervescence appears, or till the liquor becomes perfectly neutral, which may be known by the ordinary trial of syrup of violets. From this liquor, filtrated and evaporated, small crystalls are obtained, each of which has many sides, sometimes more and sometimes fewer; for the crystallization of this salt varies much in this respect. It is, in general, one of those salts, the form of whose crystals is the least constant. The greatest number of the crystals of this salt appear to have been cubes, the angles of which have been cut off.

Vitriolated tartar is one of the salts which crystallize better by evaporation than by cold. It requires a large quantity of water to dissolve it. According to Mr. Spielman's experiments, thirty grains only of this salt are soluble in an ounce of water with a heat marked by ten degrees above o in the scale of Mr. Reaumur's thermometer. Its taste is moderately saline, and somewhat disagreeable, but not acrid nor sharp. It decrepitates, when heated suddenly and strongly. It contains a small quantity only of the water of crystallization, by means of which it cannot be liquefied; neither can it be fused but by a very intense heat.

As vitriolic acid has a greater affinity with the fixed alkaline basis of the vitriolated tartar than with any other substance, excepting phlogiston, and as this alkali has a stronger affinity with this than with any other acids, hence vitriolated tartar cannot be decomposed but by means of the inflammable principle, as in the process for making artificial sulphur. Mr. Beaumé has indeed discovered that vitriolated tartar may be decomposed in the humid way, by nitrous acid alone, which disengages the vitriolic acid, and forms nitre with its alkali. But if we examine well all the circumstances of this phenomenon, we shall find that this is no exception to the general rules concerning affinities, and that phlogiston is the principal agent in this singular decomposition, as Mr. Beaume has shewn in the explication that he has given of it. *(d)*

(d) Vitriolated tartar may be decomposed by nitrous acid in the following manner, according to Mr. Beaumé. Equal parts of vitriolated tartar and nitrous acid are put into a

Vitriolated tartar may also be decomposed by means of a double affinity when it is mixed with solutions of certain metals in acids. But as by phlogiston only metals are dissolved in acids, we need not doubt that this principle has also some influence in these decompositions.

Since vitriolic acid has a greater affinity than any other acid with fixed alkali, we may therefore make vitriolated tartar by applying that acid to any neutral salt composed of an acid and a fixed alkali, as in the decomposition of nitre; and since fixed alkali has a greater affinity with vitriolic acid than any other substance, vitriolated tartar may be therefore made by applying a fixed alkali to any vitriolic neutral salt, the basis of which is not fixed alkali. Accordingly, all vitriolic salts with bases of volatile alkali, of calcareous, argillaceous, or metallic earths, may be decomposed by fixed alkalis; and the compound formed by these decompositions will always be a vitriolated tartar, consisting of the fixed alkali employed in the operation, and of the vitriolic acid of the decomposed neutral salt. Hence we may perceive, that vitriolated tartar is made in many chemical operations.

Before the theory of these operations was understood, and before the fixed vegetable alkali was known to be the same from whatever vegetable it was obtained, the several vitriolated tartars formed in different operations, and with the fixed alkalis obtained from different vegetables, were believed to be different kinds of salts, and were distinguished by different names; as the *sal de duobus*, *sal polychrest of Glaser*, *arcanum duplicatum*. But we now consider all these salts as the same vitriolated tartar, with which the other names are synonimous.

This salt is not of any use in the arts, and is but little used in chemistry. It is principally employed in medicine. Like the other neutral salts with bases of fixed alkali, it is aperitive in small doses, as a gros [72 grains]; and it is laxative, when taken from six gros to twelve. The vitriolated tartar which is prepared by decomposing nitre with vitriolic acid, called *sal de duobus*, has been much celebrated as a remedy against the effects proceeding from an extravasation of a milky humor, for which disease it has been considered as the best resolvent and evacuant. Nevertheless, as Mr. Baron well observes in his Notes on Lemery, no reason can be given for preferring this salt to other neutral salts. On the contrary, as it is one of those which are most perfectly saturated, its action and qualities must be less effectual than most of these. *See the articles* ACID (VITRIOLIC); ALKALI (FIXED VEGETABLE); CRYSTALLIZATION; *and* SALT.

DCLXXXI. TERRA FOLIATA TARTARI; FOLIATED EARTH *of* TARTAR. This name has been given improperly, and merely for

a matrass, and heated till the salt be dissolved. From the liquor, when cold, true crystals of nitre may be obtained. Mr. Beaumé believes that this decomposition is effected by means of the greater affinity of the nitrous than of the vitriolic acid to the phlogiston, which, he supposes, enters into the composition of the vitriolated tartar: and he thinks that the reason why this decomposition does not happen in the dry way or by fusion, as well as in the humid way or by cold solution, is, that the nitrous acid is in the former case dissipated by the action of the fire. This singular fact, which seems to contradict a general opinion, namely, that vitriolic acid is more disposed than nitrous acid to unite with fixed alkali, is also confirmed by the intelligent and accurate Mr. Margraaf, who further affirms, that in the same manner of treatment, vitriolated tartar, Glauber's salt, and nitre, may be decomposed by marine acid. As marine acid is certainly not more disposed to unite with phlogiston than nitrous and vitriolic acids are, Mr. Beaumé's explanation of this singular decomposition does not seem to be satisfactory.

the salt of some earthy appearance, to a *neutral acetous salt with basis of vegetable fixed alkali*, or to a combination of the acid of vinegar, saturated with the alkali of tartar or of other vegetable matters. This salt has also been called *regenerated tartar*, altho' it really be very different from true tartar, but only because the alkali of tartar is united with an acid, which in some respects is similar to the acid of tartar, but in others is very different, as may be seen at the articles TARTAR *and* VINEGAR.

The terra foliata is made, according to most dispensatories, by pouring upon a quantity of alkaline salt of tartar, in a glass-cucurbit, a sufficient quantity of good distilled vinegar, at different times, to saturate all the alkali, or even a little more than is necessary for that purpose, and till the effervescence entirely ceases. This saturated liquor is to be filtrated, and evaporated to dryness, with a gentle heat. The dry salt thus obtained is to be dissolved in spirit of wine, and the solution is to be again evaporated to dryness; by which means a salt is obtained more or less white, of a silky appearance, and composed of small scales or leaves, from which it has been called *foliated*. When the salt is dried, and while it is yet hot, it must be shut up in a well closed bottle, because it quickly becomes moist by exposure to air.

When distilled vinegar is poured upon salt of tartar, little or no effervescence is made at first; but afterwards, when more vinegar is added, the effervescence becomes so considerable, that some of the liquor will flow over the vessel, if care be not taken. This effervescence is produced by a large quantity of air that is disengaged during the saturation. Accordingly the vapor extricated during the effervescence is very *aerial*, and so pungent, that if it be confined some time in a close vessel, and then set at liberty, it is as irritating and suffocating as volatile alkali, or volatile sulphureous acid, although it be really different from either of these: for this vapor is nothing but aerial water similar to the *gas* of spirituous mineral waters. (*e*)

When the saturation is advanced to a certain degree, the effervescence diminishes, and even ceases entirely, although the saturation be not yet compleated; the reason of which is, that the last portions of acid and of alkali do not very readily combine. The combination may be facilitated by frequently agitating the liquor, by which means the effervescence may be again renewed. When the liquor cannot by agitation be made to effervesce more, it may be then allowed to stand during some time, as Mr. Beaume practises. This chemist, and very excellent observer, has remarked, that the mixture deposites a certain quantity of earthy matter proceeding from the fixed alkali, and which must be necessarily separated by filtration, to obtain a very white foliated earth of tartar. He has

(*e*) The vapor which causes the effervescence in the preparation of this salt is the fixable air that is disengaged from all mild alkaline substances by means of any acid; and the humid part of this vapor is nothing more than some particles of the effervescing liquor, which are forcibly thrown upwards by the rising air, and which form a small jet or shower above the surface of the effervescing liquor. *See* AIR (FIXABLE). The reason that this effervescence does not begin immediately upon pouring on the vinegar, is, that a part of the alkaline salt employed is generally caustic, or deprived of its fixable air, which part unites with the acid preferably to the mild part of the alkali, and absorbs any air that is extricated from this latter part: and therefore till all the caustic part of the alkali be nearly saturated, little or no effervescence can happen.

alſo obſerved, that when the alkali employed is very pure, and free from any mixture of neutral ſalts, the ſaline matter produced by the proceſs has no foliated or cryſtallized appearance.

We have already remarked, that foliated earth of tartar is a deliqueſcent ſalt. This quality proceeds from the weakneſs of the union of the acid with the alkali; the cauſe of which ſlight union is, that ſome oily and ſpirituous principles are united with the acid in vinegar. The taſte of the foliated earth is ſharp, pungent, almoſt a little cauſtic, and partaking at the ſame time of the taſte of vinegar and that of fixed alkali. This ſalt is one of thoſe that are ſoluble in ſpirit of wine. It may be decompoſed merely by the action of fire; and from it, as from any other acetous ſalt, may be obtained by diſtillation, a radical vinegar, very penetrating and very concentrated.

Foliated earth of tartar is little uſed, but in medicine. It is conſidered as a powerful reſolvent and aperitive; and it probably poſſeſſes theſe qualities, merely as it retains ſome of the action of the acid and of the alkali, of which it is compoſed. Its doſe is from fifteen or twenty to thirty-ſix grains, or even more, when no irritation is apprehended. *See the articles* ALKALI (FIXED); SALT; SALTS (NEUTRAL); *and* VINEGAR.

DCLXXXII. TERRA JAPONICA. *See* JAPONIC EARTH.

DCLXXXIII. TEST, *and* TESTING. *(f)*

DCLXXXIV. TIN. Tin is a metal, the color of which reſembles that of ſilver, but is darker and leſs white. It is ſofter, leſs elaſtic, and leſs ſonorous than any other metal, excepting lead.

When it is bent backwards and forwards, it occaſions a crackling ſound, as if it was torn aſunder.

Tin has, like other imperfect metals, a ſmell and a taſte.

It is much leſs ductile than ſome harder metals; although it may be beat into very thin leaves.

The tenacity of the parts of tin is not very conſiderable, ſince a wire of this metal, the diameter of which is $\frac{1}{10}$ of an inch, can ſupport a weight of $49\frac{1}{2}$ pounds only.

It is the lighteſt of all metals, as it loſes only $\frac{1}{7}$th part of its weight, when immerſed in water. It is very fuſible, and requires for this purpoſe a heat much leſs than is ſufficient to make it red-hot.

With the heat neceſſary for its fuſion it may alſo be calcined, or at leaſt deprived of ſo much of its phlogiſton that it appears in form of a grey calx, which cannot be reduced entirely to tin without the addition of ſome inflammable matter.

Workmen call this imperfect calx of tin, *aſhes of tin*; and thoſe who travel in the country, caſting tin ſpoons, call it *droſs of tin*. This they carefully ſkim off, pretending thereby to purify their tin. But they preſerve this pretended droſs, and reduce it to tin by melting it with ſome pitch.

Theſe aſhes of tin, like other calxes of metals, may be further deprived of phlogiſton, by a calcination continued with a more intenſe fire, by which means

(f) TEST *and* TESTING. A teſt is a large kind of cupel uſed in operations for refining large quantities of gold and ſilver by means of lead; and the operation is called *teſting*. *See* CUPEL; CUPELLATION, *and* REFINING.

it becomes more and more white, hard and refractory. It is then called *putty*, and is used in the arts for polishing glafs and other hard bodies.

Calx of tin, very white and well calcined, is a very refractory fubftance. Its beautiful whitenefs and refractory quality render it capable of forming, together with fome fufible and vitrifiable matters, a white enamel, which is uied as a white glazing or covering for delf-ware. *See* DELF-WARE.

The moft ordinary method of preparing this putty, is by mixing together lead and tin, and expofing this mixture to a ftrong heat. Thefe two metals have been found to be more eafily calcinable when mixed than when fingle. By adding to the calx thus obtained fome fand and vitrifiable falts, and by fufing the mixture, a very beautiful white enamel may be made: for lead does not, like tin, lofe its fufible quality by calcination.

I have expofed very pure tin, fingly, to a fire as ftrong as that of a glafs-houfe, during two hours, under a muffle, in an uncovered teft; and having then examined it, I found it covered with an exceedingly white calx, which appeared to have formed a vegetation; and under this matter, a reddifh calx, and a tranfparent hyacinthine glafs; and laftly, at the bottom, a piece of tin unaltered. This experiment was feveral times repeated with the fame fuccefs.

Nitre mixed with tin may be inflamed, and it haftens confiderably the calcination of this, as it does of other imperfect metals. The vapors which rife during the feveral calcinations of this metal have generally an alliaceous or arfenical fmell; becaufe tin generally contains fome arfenic, as Mr. Margraaf has obferved.

Although tin be one of the moft calcinable metals by means of fire, it is much lefs apt to ruft by the combined action of air and water, than iron and copper. Its furface, when it is clean and fhining, lofes indeed its luftre, and tarnifhes quickly by expofure to air, but the flight kind of ruft which is there formed remains thin and fuperficial, and does not advance fo deeply into the fubftance of the metal as the ruft of iron and of copper generally does. Hence tin is advantageoufly employed to cover many utenfils made of thefe metals. *See* TINNING.

Every acid is capable of attacking or diffolving tin.

Vitriolic acid requires to be affifted by a certain degree of heat to diffolve tin efficacioufly. I have obferved, that during this folution fulphureous vapors are raifed; and I have even feparated fome black particles, which I have found to be true inflammable fulphur. The production or extraction of this fulphur requires a particular examination. *See* SULPHUR.

Nitrous acid attacks tin with very great violence, efpecially when the metal is much divided. But when the acid is very pure, it rather corrodes and calcines than diffolves tin. As the phlogifton of this metal is not very ftrictly engaged, the nitrous acid chiefly attacks it by means of this principle, which it feizes, and feparates from the tin, that is thus reduced to an unfoluble white earth, or calx, depofited at the bottom of the acid. This calx of tin made by nitrous acid appears to be as perfectly dephlogifticated, as that which had been expofed during a long time to fire. I have attempted unfuccefsfully to reduce it to its metallic ftate. This calx makes a very good white enamel.

The

The acid of common salt dissolves tin perfectly well by help of heat. I have observed, that when I put a considerable quantity of fine granulated tin into a matrass, and poured some smoking, and consequently colored, spirit of salt upon it, that the acid quickly ceased to smoke, and lost its color; that it attacked the tin with a sensible but moderate effervescence, and became saturated with it. This acid dissolved more than half its weight of tin. The vapors which rose during the solution had a disagreeable arsenical smell; and the solution when saturated was clear and colorless as water. Having kept the solution in a bottle, I observed that, during the winter, it almost all crystallized, and that the crystals became fluid during summer. Some years afterwards a white sediment was formed in this solution.

Tin has a greater affinity with marine acid than some other metallic substances which have also much affinity with this acid; for it separates the marine acid from luna cornea, from corrosive sublimate, and from butter of antimony. When tin is mixed, especially with corrosive sublimate, it decomposes this salt, even without heat; and the mixture produced becomes moist by exposure to air. If it be distilled before it has imbibed much moisture, a very smoking spirit of salt, called *smoking spirit of Libavius*, is obtained. *See* SPIRIT (SMOKING) *of* LIBAVIUS.

This acid retains much tin dissolved, some of which it raises along with it in distillation, as it does several other metallic matters. Accordingly, in this distillation, a concrete, saline, metallic matter is sublimed, that may be called *butter of tin*: which name has been given by some chemists to the smoking spirit.

From the detail we have given of the solutions of tin by nitrous and marine acids we may perceive, that the former acid deprives it of all its inflammable principle, but has no action upon its dephlogisticated earth; and that the effects of the marine acid upon this metal are quite the reverse. Accordingly, when these two acids are united together, forming an aqua regia, they compose a menstruum, which acts very efficaciously upon tin, on account of the activity of the nitrous acid, but which does not destroy the metal, as nitrous acid singly does, because the action of this acid is moderated by the marine acid: hence, the more nitrous acid is contained in aqua regia, the more similar are its effects upon tin to those produced by nitrous acid alone; and reciprocally with regard to marine acid.

A good solution may be made of tin in aqua regia, if attention be given to the following particulars. A small quantity only of tin ought to be put into the acid, and no more added till the first piece be entirely dissolved; because when much tin is added at once, the heat occasioned by the solution encreases the activity of the solvent so much, that the tin is as much calcined and precipitated as if pure nitrous acid had been employed; but when the tin is added gradually, and the heat is thus restrained, the aqua regia may be so charged with this metal, that it shall be thick and viscid, like a a liquid transparent resin. The solution thus charged has a yellow-reddish color.

We may observe, that in this solution there is a considerable quantity of tin upon which the nitrous acid of the aqua regia has not exhausted all its action, although this menstruum seems to be more than saturated; for I have observed, that when this liquor is heated, an effervescence happens entirely similar to that which

which is occasioned during the solution of metals by acids. This effervescence lasts till the parts of the tin which were only half dissolved have been redissolved a second time; after which the solution is found to have lost its color. Sometimes this solution becomes quite fixed or solid when it cools, and appears like a firm jelly, and transparent as crystal.

All the solutions of tin are acid and corrosive; and may be decomposed by being diluted with much water; in which case, the tin is copiously precipitated in form of a white calx.

When a solution of tin is mixed with a saturated solution of gold, and when the mixture is diluted with a large quantity of water, a purple precipitate is formed, called *purple powder of Cassius. See that word.* This powder is employed for painting on enamels and on porcelain.

The solution of tin in aqua regia, added to the tinctures of cochineal, of gum lac, and of some other red tinctures, heightens the color of these, and changes it from a crimson or purple to a vivid reddish-yellow or fire-colored scarlet. Dyers call this solution of tin, with which they give a scarlet tinge, *the composition.* We may observe, that this color succeeds only with wool and other animal matters. Attempts have been made, but without success, to give this color to thread, to cotton, or even to silk, although this latter substance has many properties of animal matters.

I have also observed, that the larger quantity of nitrous acid is contained in the aqua regia, which dissolves the tin, the nearer does the red color communicated to cochineal approach to the vivid yellow; so that the solution of tin made with marine acid alone, or with vitriolic acid, do only give to red tinctures a crimson color, as alum does. *See* DYING.

Vegetable acids, as vinegar and cream of tartar, are also capable of dissolving tin: but the properties of these solutions have not yet been well examined.

Tin, according to Mr. Geoffroy's table of affinities, has a stronger affinity with the acid of common salt than regulus of antimony, copper, silver, and mercury; because the combinations of this acid with these metals are decomposed by tin, which precipitates them, and unites with the acid.

Sulphur may be united with tin by fusion, and forms with it a brittle mass, more difficultly fusible than pure tin. Sulphur has in this respect the same effect upon tin as upon lead. The allay of sulphur lessens the fusibility of these very fusible metals, while it encreases the fusibility of other difficultly fusible metals, as of iron and copper.

Tin may be allayed with all metals by fusion, and in all proportions; but it absolutely destroys their ductility. A remarkable circumstance is, that the most ductile metals, as gold and silver, are those the ductility of which is most injured by tin. The vapor of a single grain of tin is capable of rendering a considerable quantity of gold brittle. The ductility of copper is less injured by tin than that of other metals, although it is considerably injured. A singular circumstance concerning this allay is, that tin, although a very soft metal, and not at all sonorous, augments considerably the stiffness, the hardness, and the sonorousness of copper, as we see in *bell-metal.*

The allay, or amalgam of tin with mercury, is employed to cover one of the surfaces of looking glasses, by which they are rendered capable of reflecting the

rays of light, and of forming mirrors. This covering of tin and mercury, which is applied upon glasses, is called *tinning*.

Tin, allayed with an equal quantity of lead, forms the solder used by plumbers.

According to Mr. Gellert's table, the affinities of tin are, iron, copper, silver, and gold. *See, for the allays of tin, the words* ALLAY, AMALGAM, *and* BRONZE.

Tin is not much used in medicine, and for good reasons: for we find, from a long Dissertation by Mr. Margraaf upon this metal, that tin generally contains more or less of an arsenical matter, which probably proceeds from the ores of tin, as all these contain arsenic. *See* ORES, *and* SMELTING *of* ORES. Mr. Margraaf discovered this arsenical part of tin chiefly in the humid way, and by solution in acids. The white calx of this metal is commonly employed in the preparation of the *antihectic of Poterius*, and of the *lilly of Paracelsus*: but this calx is unsoluble and ineffectual; besides, it appears to furnish no part of the lilly.

Tin is very extensively useful in many arts, as we may judge from what has been said of the different preparations of this metal.

DCLXXXV. TINNING *of* COPPER, *and of* IRON. Tinning is an operation by which a very thin layer of tin is applied to the surface of some metals, and especially of copper and of iron. The methods of tinning these two metals are different. Copper is tinned after it has been formed into utensils, and by the copper-smiths who form these utensils. The tinning of iron is performed upon thin plates of iron, in particular manufactories in France, in Germany, and in some other places. Workmen, called *tin-smiths*, do only form these plates, which are brought ready made from their proper manufactories, into the various utensils required.

The several operations for tinning of copper and iron are founded, first, on the facility with which tin unites with these metals, which is so great, that when either of these metals are tinned, the tin only requires to be melted, and the others on which it is to be applied do not. Nevertheless, the tin incorporates with these metals, dissolves in some measure their surface, and forms a kind of allay, at least when the tinning is well performed.

Secondly, the foundation of all the parts of the operation used to make the tinning succeed is, that metals cannot penetrate and unite with each other but when they are in a metallic state, and that they cannot unite with any earthy matter, not even with their own earths or calxes.

Hence, the whole art of tinning consists in applying melted tin, the surface of which shall be very clean, metallic, and not covered with any ashes or calx of tin, to the surface of iron or of copper, which must also be very clean, and free from all rust or calx.

To attain these purposes, the following method is used. As the surface of copper is continually altered merely by the action of air, the workmen, before the tinning of any vessel, scrape its surface with a steel instrument till it be clean and bright: then they place the vessel upon kindled coals, and heat it to a certain degree: as soon as it is hot, they rub it with pitch; and then apply the melted tin, which they spread upon the surface of the copper by

by means of hards. Pure tin is ſeldom uſed for this purpoſe; but generally two parts of tin are allayed with one part of lead.

The pitch uſed in this operation is quite neceſſary, becauſe the degree of heat given to the copper is ſufficient to calcine its ſurface in ſome meaſure; and this alteration, however ſlight, would prevent the perfect adheſion of the tin, unleſs, by means of the pitch, the phlogiſton was reſtored to it at the very inſtant of the application of the tin. This pitch prevents alſo the ſlight calcination which would happen on the ſurface of the tin, or revives the ſmall particles of calx which are formed during the operation.

When plates of iron are to be tinned, they muſt be perfectly well cleanſed, which is done by ſcouring them with ſand, and ſteeping them ſome time in acid liquors: then they are to be wiped, and dried quickly and perfectly. Laſtly, they are to be plunged vertically into a veſſel containing melted tin, the ſurface of which is covered with fat and pitch. Theſe fat ſubſtances covering the ſurface of the tin, ſupply it continually with phlogiſton, prevent its calcination, by which its adheſion to the iron would be impeded, and alſo render the ſurface of the iron, while it paſſes through them, fitter to receive the tin. By thus plunging plates of iron into melted tin, they are covered over with this metal, or are tinned.

Sal ammoniac is alſo uſed ſucceſsfully in the tinning of iron and of copper, and always for the ſame reaſon. The acid of this ſalt perfectly cleans the ſurface of the metals to be tinned, and alſo the oily matter contained in ſal ammoniac furniſhes the phlogiſton that is neceſſary in this operation. Thus, by heating theſe metals to a certain degree, and rubbing them with ſal ammoniac, the tin may be applied immediately afterwards.

The advantages derived from tinning are very conſiderable. As tin is a ſoft and fuſible metal, veſſels formed of it alone would not have ſufficient ſtrength and hardneſs to keep their ſhape in common uſe, and would alſo be liable to be melted with a ſmall heat: but when it is applied to the ſurface of hard and difficultly fuſible metals, as copper and iron, many veſſels may be fabricated, which have the advantage of being preſerved, by means of the tin, from ruſt, to which the copper and iron are very ſubject. It has been, nevertheleſs, juſtly alledged, that copper veſſels are not perfectly prevented from ruſt or verdigriſe by tinning; and this fault is ſo much more important, as tinned copper veſſels are generally uſed for the preparation of victuals. Theſe veſſels therefore, even when tinned, ought not to be employed for this purpoſe; eſpecially as tin itſelf is ſuſpected of being hurtful to health, ſince Mr. Margraat diſcovered that arſenic is contained in almoſt all tin; and alſo becauſe lead, a moſt hurtful metal, is uſed in tinning. Nevertheleſs, tinned copper veſſels may be uſed for many other purpoſes. Beſides, the tinning of copper and iron veſſels may be improved, by attending to the fundamental principles of this art delivered in the preſent article.

DCLXXXVI. TINNING *of* LOOKING-GLASSES. This operation conſiſts in applying an amalgam of tin and mercury upon one of the ſurfaces of looking-glaſſes, by which they are rendered much more capable of reflecting the rays of light, and conſequently of repreſenting, in a clear and lively manner, the images of objects.

This effect of the tinning of looking-glasses is founded on the superior opacity, and consequently on the superior reflective power of metallic to all other substances.

Glasses to be tinned are placed upon tables, in a perfectly horizontal or level situation. The surface, previously well cleaned, is to be covered with tin-leaves, which also must be very clean. Upon these is poured a sufficient quantity of mercury to cover the whole surface, and it is allowed to rest some time, that it may amalgamate perfectly with the tin-leaves: then a small degree of inclination is given to the glass, that the superfluous mercury may run off; which inclination must be gradually encreased till the glass be at last brought to a vertical situation, by which means no more mercury remains than is really amalgamated with the tin. As the surface of the glass is exceedingly smooth and well polished, the amalgam is in very perfect contact with it, and therefore firmly adheres to it.

The success of this operation depends much on the cleanness of the surface of the glass; for the least dirt or dust interposed betwixt the amalgam and the surface of the glass would absolutely prevent the adhesion of contact between these two bodies.

Since vitrified matters, as glasses are, cannot unite intimately with metallic substances, the adhesion of the amalgam upon the glasses is not so strong as that of metals upon metals; as in the tinning of copper and of iron, in which there is a solution, a penetration, and an intimate union of the tin with the surface of the tinned metal: but in the tinning of looking-glasses, there is only the adhesion of contact, or of a perfect juxtaposition, which may take place between any bodies, however heterogeneous, by the application of their polished surfaces. Accordingly, this metallic covering may very easily be taken off, and ought to be preserved from moisture, and from any kind of rubbing, however slight. For which reason, the superfluous mercury must be made to run off very gently and slowly, otherwise all the amalgam might fall off by its weight.

DCLXXXVII. TINCAL. *(g)*

DCLXXXVIII. TINCTURE. By this name are distinguished, in chemistry and pharmacy, all spirituous liquors that are colored by being digested upon different substances. These are, properly speaking, infusions in ardent spirits.

Many chemical preparations are called *tinctures*. We shall treat of some of the chief of these.

DCLXXXIX. TINCTURE (ALKALINE). *See* TINCTURE *of* SALT *of* TARTAR.

DCXC. TINCTURE *of* ANTIMONY. This tincture is made, according to the Paris Dispensatory, in the following manner: Let a mixture of one part of crude antimony with two parts of the alka-

(g) TINCAL. Borax, in the crude state in which it is brought from India, and before it is refined, is called tincal. It consists of small crystals, of a yellowish color, and it has a greasy or unctuous touch. According to Mr. Cadet, it contains a larger quantity of the peculiar vitrescible earth of borax, than the refined salt commonly sold does. *See* BORAX, *and* SALT (SEDATIVE).

fine salt of tartar, be fused in a covered crucible, and the fusion continued during an hour. The melted matter is to be poured out; and as soon as it has become solid, it is to be pulverised: while yet hot, it is to be put into a matrass; and upon this powder rectified spirit of wine is to be poured, to a height above the powder equal to the breadth of three fingers. This tincture is to be digested with a gentle heat during several days, by which it acquires a deep red color; and then it is to be decanted and preserved in a well-closed bottle.

In this fusion of crude antimony with fixed alkali, a liver of sulphur is formed, which dissolves the reguline part of antimony. It is consequently an antimoniated liver of sulphur, nearly of the same nature as that of which *kermes mineral* is made: but in the present operation this matter is not dissolved in water, but is digested in spirit of wine; which menstruum seems to dissolve a part of the whole matter, that is, a part of the liver of sulphur, and by means of it also some of the regulus of antimony; for this tincture acquires a red color, and produces nausea, according to Lemery, when taken internally. According to the same author, the dose of this tincture is from four drops to twenty, and is to be administered in some proper liquor.

The medicinal effects of this preparation may be very good, and analogous to those of kermes; but it is not much used. *See* KERMES (MINERAL).

This solubility of antimoniated liver of sulphur in spirit of wine is remarkable: but an explanation of all the appearances that occur in this and in several other operations, would require more particular researches than have yet been made.

DCXCI. TINCTURE *of* MARS. Iron, being a metal much employed in medicine, has been prepared in various manners for internal use. Amongst the principal of these are the following tinctures.

DCXCII. TINCTURE *of* MARS (LUDOVICUS's). This tincture is made, according to the Paris Dispensatory, in the following manner: Four ounces of martial vitriol calcined to whiteness are to be mixed with an equal quantity of cream of tartar, and this mixture is to be boiled in a pound and a half of water, till the whole has acquired the consistence of honey. This mass is to be put into a matrass, into which some rectified spirit of wine is to be poured to a height equal to the breadth of four fingers. After a digestion during some time in a sand-bath, the tincture is to be decanted, and fresh spirit of wine is to be poured on the residuum, and digested as before. These operations are to be continued as long as the spirit of wine acquires color; and, lastly, all these tinctures are to be mixed together and preserved for use.

The theory of this process is not well known; because all the circumstances have not been examined with sufficient attention. We see, indeed, that the cream of tartar ought to act upon the portion of the iron of the martial vitriol, which does not adhere very strongly to the vitriolic acid, or which is even quite disengaged from that acid by calcination; and that this combination of iron with cream of tartar may be soluble in spirit of wine, to which it may communicate color, and consequently may form the present tincture: but does not the cream of tartar act also upon the iron which is united with the vitriolic acid; and if it does not act, does the martial vitriol dissolve in spirit of wine?

 If

If it does not dissolve in this spirit, when it is single and in its ordinary state, and charged with much iron, may it not become soluble either when it has deposited a part of its iron, or by means of the acid of tartar? These are questions which, I believe, have not been yet examined; but which must be ascertained, before we can know precisely the nature of this tincture of Mars. For its medicinal virtues, *see the article* IRON.

DCXCI. TINCTURE *of* MARS *of* MYNSICHT. This tincture is made by digesting the martial flowers of sal ammoniac with a sufficient quantity of rectified spirit of wine in a matrass.

Spirit of wine dissolves the salt formed by the union of iron with the acid of sal ammoniac; but as this spirit can also dissolve the sal ammoniac itself, it may be charged with a certain quantity of the latter salt in this operation: it is even very possible, that by means of this sal ammoniac, it dissolves a greater quantity of the martial salt than it would otherwise do; and reciprocally, that the martial salt puts it in a condition of dissolving a greater quantity of sal ammoniac; which effects are similar to those produced by treating in the same manner corrosive sublimate and sal ammoniac in spirit of wine: but I do not believe that any researches have been made to elucidate this subject. Chemists, who have given receipts for most of the medicinal preparations of the kind of which we now treat, made frequently capricious mixtures, the effects of which they did not know. These preparations have been consecrated by use, although little trouble has been taken to ascertain their nature: but now that chemistry, taken in its true and genuine spirit, has become a science as accurate and rigorous in some measure as geometry, all these ancient receipts ought to be scrupulously examined. We should then certainly reject many of these for their unfitness to produce the effects expected, and we should know better the virtues of those which should be judged worthy to be retained in use. Probably the tincture of Mars of Mynsicht possesses the medicinal qualities of iron dissolved by marine acid, and of sal ammoniac.

DCXCIII. TINCTURE *of* MARS (ALKALINE) *of* STAHL. This preparation, the knowledge of which Stahl has communicated to us, is a solution of iron in fixed alkali. Although this saline substance be capable of acting directly upon iron, and of dissolving it in some measure, this combination succeeds much better when the iron to be united with the alkali is previously divided by being dissolved in an acid, and especially in nitrous acid, as Stahl has shewn.

According to the process of this celebrated chemist, the iron ought to be previously dissolved in nitrous acid, and the solution ought to be as perfectly saturated as possible. This saturated solution is to be added at several different times to a strong solution of vegetable fixed alkali. Each time that the solution of iron is poured into the alkaline liquor, a kind of precipitate or coagulum of a deep red saffron color is instantly formed: but this precipitate disappears soon after, and dissolves entirely in the alkaline liquor, to which it communicates a deep-red yellowish color. More of the solution of iron is to be poured into the alkaline liquor, till the precipitate is no longer redissolved. Lastly, this solution, which is the martial alkaline tincture of Stahl, is to be filtrated.

We may easily conceive what passes in this process. The alkali, into which the combination of iron with nitrous acid is poured, decomposes at first this combination,

combination, by uniting with the acid, and precipitating the iron. But as there is much more alkali than is required to saturate the quantity of acid added, the uncombined portion of alkali finding the iron in a very divided state, attacks and dissolves it perfectly.

Iron is not the only metal that may be thus dissolved by an alkali. Almost every metal is more or less soluble by alkalis, as Mr. Margraaf has shewn. *See his Opuscules Chymiques, Diss.* III. This celebrated chemist found that not very pure alkalis but alkalis phlogisticated by calcination with ox's blood and volatile alkali, were fit for this purpose.

This solution of iron in fixed alkali does not always succeed, and even sometimes fails, when all the circumstances directed by Stahl have been observed. I have remarked, and also Mr. Beaumé, that it succeeds much more constantly, and almost certainly, when a solution of iron not nearly saturated and very acid is employed; and when the solution has not the reddish-yellow color of rust that saturated solutions have, but is clear and limpid, or only slightly greenish. We were also induced to believe, that a similar excess of acid was favorable for redissolving other metallic precipitates from their acid menstruums by means of alkali; and even that without this excess, the operation cannot succeed. But Mr. Marges, an intelligent chemist, has shewn me a solution of iron much impregnated, and high-colored, the iron of which might be perfectly dissolved by fixed alkali, without heat; and which constantly formed the martial alkaline tincture, either by pouring the solution to the alkali, or the alkali to the solution; which proves that this phenomenon depends on the concurrence of several circumstances; as on the state of the iron in the nitrous acid, which is known to be very variable; on the greater or less phogistication of the alkali; and perhaps also on several other circumstances, which ought to be more fully examined, before we can form a judgment.

The martial alkaline tincture certainly contains an iron very much divided, in a saline and perfectly dissolved state, though it is not united to any acid; and as it also possesses a saponaceous alkaline character, it may be very useful in all cases where martial and anti acid remedies are at the same time indicated: and these cases are very frequent, as practical physicians well know.

A very fine saffron of Mars may be separated from this solution, either by precipitating the iron by gradually saturating the alkali with any acid, or by a spontaneous deposition of a ferruginous sediment, which is slowly formed in this, in the same manner as in the acid solutions of iron. We shall only observe, that the iron which has been thus dissolved by an alkali is very soluble in acids; so that when it is to be precipitated by an acid, we must take care not to add a drop more than is necessary for the perfect saturation of the alkali, otherwise all the precipitate instantly disappears, and the liquor becomes clear and almost colorless. *See* ALKALI *and* IRON.

DCXCIV. TINCTURE *of* MARS (TARTARISED). This preparation, like the preceding, is called a tincture, although it contains nothing spirituous, but merely from its deep color. It is a solution of iron by the acid of tartar; and is a true *Martial soluble tartar*, as we shall see.

This combination is made, according to the Paris dispensatory, in the following manner. Six ounces of clean filings of iron, and a pound of powdered white

they are to be mixed together in an iron vessel; the mixture is to be moistened with a sufficient quantity of water to form it into a mass, which must be left and stirred during 24 hours, that the acid of tartar may begin to act upon the iron. Then six Paris pints [12 pounds] of pure water are poured on the mixture, and boiled together during two hours. From time to time the mixture must be stirred during the boiling, and hot water is added to supply the place of that which is evaporated. The liquor is then to be left to settle, and to be filtrated and evaporated to the consistence of a liquid syrup. Lastly, an ounce of spirit of wine is to be added to it, to prevent the solution from becoming mouldy.

In this operation, the acid of tartar dissolves the iron, becomes saturated, and forms with it a neutral salt, which is not only very soluble in water, but which is even very deliquescent: hence this salt cannot be crystallised, but is obtained in the state of a liquor, or of an extract, sometimes dry and sometimes soft, according as it has been more or less evaporated. The color of this salt is red, or brown, and its taste is the same as that of all salts the bases of which are iron, though somewhat less austere and styptic.

The union of the acid of tartar with iron is very weak and very superficial in this combination; and hence this salt is very deliquescent. This deliquescence is surprizing, considering that, as we have remarked elsewhere, the two substances which compose it have little or no solubility in water. From this difficult solubility in water of the component parts of the tartarised tincture we may conclude, that in whatever proportions these parts are mixed together, this tincture must always be a neutral salt, perfectly or nearly saturated: for if any portion of tartar be not combined with the iron, it will remain at the bottom of the vessels, or upon the filter; and the same observation may be applied to the iron that is not combined with the tartar. Nevertheless, as pure tartar is soluble in water, and as consequently a small portion of it may remain unsaturated in the liquor, it would be proper, if this martial soluble tartar be required perfectly neutral, to add more filings of iron than are sufficient to saturate all the acid; because the superabundant quantity could not remain in the solution, and because by this method of employing a large quantity of filings, the operation may be much shortened; whereas it would be very long, if no more filings were employed than is required for the saturation of the tartar, and if at the same time all the tartar was required to be saturated.

The tartarised tincture of Mars has the same medicinal qualities as the other saline and soluble preparations of iron; but it is, as we have said, the least styptic. Accordingly, in cases where martial preparations are indicated, and at the same time the styptic quality of iron is apprehended, this is one of the best preparations of iron that can be prescribed. It does not essentially differ from the infusion of martial balls. *See* Iron, *and* Tartar.

DCXCV. TINCTURE *of* METALS, *or* LILLY *of* PARACELSUS. This preparation may be made by several processes; but as they do not much differ, we shall here give the easiest and readiest.

Two parts of martial regulus of antimony, one part of fine tin, and one part of pure copper, are melted together in a crucible. The allay thus compounded

pounded is to be powdered, when cold, and mixed with thrice its weight of purified nitre. The mixture is to be thrown at different times into a red-hot crucible, where it detonates, and is exposed to a violent fire, till the metals be perfectly reduced to calxes. The matter is to be taken from the crucible while red-hot, and immediately thrown into a heated iron mortar, where it is quickly powdered. The powder is to be put, while yet hot, into a matrass, and upon it some rectified spirit of wine is to be poured to a height equal to the breadth of four fingers. The digestion is continued during some days, or till the spirit of wine has acquired a very deep yellowish red color. The spirit is to be decanted and kept in a bottle; and is called the *Tincture of Metals*, or *Lilis of Paracelsus*.

From this name *Tincture of Metals*, we find that the spirit of wine was supposed to extract something from the metals on which it is digested in this process; perhaps its color gave rise to this opinion. Nevertheless, as Mr. Baron well observes in his Notes on Lemery, if we consider that the metallic matters are reduced almost to the state of pure earths by calcination, we shall be convinced that no part of them can be dissolved by the spirit of wine. Besides, Mr. Beaumé, having particularly examined this preparation, was convinced by experiments that no metallic matter can be separated from it. But although it contains no metallic matter, we do not say that it is ineffectual, or that it has no other qualities but those of the pure spirit of wine. On the contrary, we know that the nitre is alkalised in this operation; and that this alkali, which is capable of being rendered as caustic by metallic calxes, as it is by quicklime, acquires a power of acting singularly and effectually on spirit of wine, which it partly decomposes. This alkali either forms with the spirit of wine, or it separates from this spirit, an oil, with which it combines, and to which it gives color, and a very acrid taste. Hence the tincture of metals resembles much the *tincture of salt of tartar*, of which we shall afterwards treat, and like which it has a spirituous, saponaceous, acrid, and alkaline character. Accordingly, it is successfully used when the fibres and vessels require to be excited and animated; as in apoplexies, palsies, dropsies. For the same reason, it is capable of accelerating the motion of the blood, and of encreasing certain secretions and excretions, particularly sweat and urine. The dose of this tincture is from six or twelve drops to forty or even more, and it must be administered in some proper cordial.

DCXCVI. T I N C T U R E *of* G O L D. *See* GOLD (POTABLE).

DCXCVII. T I N C T U R E *of* S A L T *of* T A R T A R.

This tincture is made by pouring some rectified spirit of wine to a height equal to the breadth of three or four fingers, into a heated matrass that contains some hot salt of tartar, which had been previously fused in a crucible and powdered. The matrass is to be closed, and the digestion is to be continued during several days with a gentle heat, or till the spirit of wine has acquired a fine reddish yellow color.

This preparation is essentially the same as the tincture of metals, as in both these, the fixed alkali acts upon and colors the spirit of wine; with this difference only, that as the alkali of tartar, in its ordinary state, is much less caustic than when it has been calcined with metallic calxes, it therefore acts less quickly

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and powerfully in the tincture of falt of tartar than in the tincture of metals. Accordingly the former preparation is more deeply colored than the latter. But if in the preparation of the tincture of falt of tartar, an alkali previoufly rendered cauftic by quicklime be employed, the tincture will be as red and active as the tincture of metals; and hence the medicinal qualities of thefe two tinctures are the fame.

DCXCVIII. TINCTURES *of* VEGETABLE *and* ANIMAL SUBSTANCES. Many medicinal preparations are called tinctures, becaufe they are made by digefting certain vegetable and animal fubftances in fpirit of wine, to which they communicate different colors, according to their nature.

Some of thefe tinctures are made with one vegetable or animal fubftance only. Thefe are called *fimple tinctures*, and they are diftinguifhed by the name of the vegetable or animal matter employed; fuch are the tinctures of myrrh, of aloes, of faffron, of caftor, and many others.

Others contain a greater or lefs number of different vegetable and animal fubftances, which are digefted in fpirit of wine, according to the feveral receipts. Thefe have the general name of *compound tinctures*, and are alfo diftinguifhed by the names of their particular authors and qualities.

We fhall not here enter into a detail of thefe feveral tinctures, becaufe they are rather objects of pharmacy than of chemiftry; but fhall confine ourfelves to the following general obfervations.

Firft, as vegetables and animals are compofed of feveral principles which are not all foluble, or not equally foluble in fpirit of wine, we cannot confider fpirituous tinctures as complete extracts of the vegetable and animal fubftances employed in their preparation.

Secondly, the principles of thefe fubftances upon which fpirit of wine can act, are volatile effential oils, and others of the fame nature; refins, properly fo called; any oils that are in a faponaceous ftate, and foluble in water by means of fome faline matter; acids; and laftly, feveral kinds of neutral falts. And the principles which fpirit of wine cannot diffolve directly are fweet oils and oily concretions that are not volatile nor faline; fubftances purely gelatinous and gummy; earthy matters not faline nor foluble in water; and laftly, many neutral falts, which are infoluble in fpirit of wine, the v[illegible] kinds of which have not yet been determined.

Thirdly, many of the vegetable and animal principles that are effentially infoluble in fpirit of wine, particularly gums, jellies, and neutral falts, foluble in water.

Fourthly, from the laft obfervation we may perceive, that tinctures drawn from the fame vegetable or animal fubftance muft differ confiderably according to the ftate of drynefs of thefe fubftances, and the dephlegmation of the fpirit of wine employed. For a tincture made from moift plants, and with a weak fpirit of wine, muft contain fome gummy and faline principles, which could not be contained in a tincture made with the fame plants perfectly dried, and a fpirit of wine perfectly rectified.

Fifthly, as many chemical experiments fhew that fubftances naturally unfoluble in any certain menftruum, may be rendered foluble in that menftruum by

by some other intermediate substance; and as, amongst the vegetable and animal principles, some such intermediate substances may exist; we cannot therefore affirm that spirituous tinctures contain no other of these principles but such as are naturally soluble in spirit of wine; but we rather think that they probably do contain other principles. This subject has not been examined sufficiently to enable us to speak upon it in a less vague and general manner than we now do. *See* ANALYSIS *by* MENSTRUUMS, *and* SPIRIT (ARDENT).

DCXCIX. TIN-GLASS. This name is frequently given to the semi-metal bismuth. *See* BISMUTH.

DCC. TOBACCO. (*h*)

DCCI. TOPAZ. (*i*)

DCCII. TORREFACTION. This name is given to a kind of calcination by which ores are deprived of the volatile mineralising substances, the sulphur and arsenic which they contain. It is also applied to signify the roasting of some pharmaceutical preparations. Thus, for instance, we say *torrefied rhubarb*, &c.

DCCIII. TRAGACANTH (GUM). *See* GUM.

DCCIV. TRIPOLI. (*k*)

DCCV. TRITURATION is an operation which consists in the mechanical division of bodies, and is executed by the same methods, and by the same instruments, that are employed for other divisions of this kind; that is to say, in mortars, upon porphyries, and in mills. *See* DIVISION. This word is generally applied to denote the division that is made of several bodies together, to unite them with each other; as, for instance, the extinction of mercury in the operation of ethiops mineral, and others similar.

DCCVI. TURBITH MINERAL. This name is given to a preparation of mercury made in the following manner.

(*h*) TOBACCO. The leaves of this plant being distilled in a retort, without addition, yield an acrid, empyreumatic, poisonous oil. Tobacco loses its virulence by long coction in water. From an ounce of American tobacco, water extracted four drams and thirty grains; and from an ounce of the same tobacco, spirit of wine extracted one dram and thirty grains. The spirituous extract was stronger than the aqueous. The former had a fine green color; the latter was yellowish-brown. The distilled water and spirit of tobacco have no taste or smell. *Neuman.*

(*i*) TOPAZ is a precious stone, of a golden color, the fourth in hardness from diamonds. Mr. Pott has made some curious experiments on the Saxon topaz. He found that this stone could not be fused with even eight times its weight of fixed alkali, but that it was vitrifiable by addition of half its weight of borax, or of thrice its weight of chalk. It was also fused by calxes of lead or of copper, and by fusible spar, but not by nitre.

This stone may be imitated by fusing a mixture of two ounces of powdered rock-crystal with seven ounces of red-lead.

(*k*) TRIPOLI is an earth consisting of very fine particles. It is used for polishing hard bodies. Tripoli is not fusible in the fire. Its colors are various; grey, yellow, white. It becomes more hard and compact in the fire, as clay does; and from this property probably it has been considered as an argillaceous earth; tho' it does not appear to have been sufficiently examined. It has been imagined to be a powder formed by the decomposition or mouldering of jasper. Neuman says, that by distilling two ounces of it, he obtained two scruples of a weak marine acid, and a small portion of sal ammoniac; that by distilling a mixture of this earth and nitre he obtained an aqua regia; and that of sixty grains of Tripoli, one grain was soluble in concentrated vitriolic acid, two in diluted vitriolic acid, three in spirit of salt, five in spirit of nitre, eleven in aqua regia, and seven grains in caustic fixed alkali.

Some mercury is put into a glass-retort, and upon it is poured an equal weight of concentrated vitriolic acid, or more, according to the degree of concentration of this acid. These matters are to be distilled together in a sand-bath till nothing remains in the retort but a dry saline substance, which is a combination of mercury with vitriolic acid. The union of these two matters cannot be directly effected but by this process, because the vitriolic acid cannot attack mercury unless it be highly concentrated, and because this concentration cannot be performed so well in open as in close vessels. *See* CONCENTRATION. Besides, the heat in this operation favors considerably the action of the acid upon the mercury. The acid which passes into the receiver during the distillation, is very suffocating and sulphureous; which qualities it receives from the phlogiston of the mercury.

The white saline mass left at the bottom of the retort is to be put into a large vessel, and upon it large quantities of hot-water are to be poured at several different times. This water weakens the acid, takes it from the mercury, which is then precipitated towards the bottom of the vessel in form of a very shining yellow citron-colored powder. This yellow mercurial powder, having been well washed, is called *turbith-mineral*, and is a very powerful emetic.

The water with which it is washed contains the acid that was united with the mercury; but it also contains a little mercury, that remains in a saline state, and is soluble in water, by means of the very large quantity of acid.

Most chemists, especially Mr. Rouelle, have believed that a portion of vitriolic acid remains united with the turbith mineral, but too little to render it soluble in water. On the contrary, Mr. Beaumé, having examined this matter, affirms that turbith mineral contains no acid, when it has been sufficiently washed; and that by frequently boiling this preparation in a large quantity of distilled water, not a vestige of acid will adhere to it.

Turbith mineral may also be made, by precipitating mercury from its solution in nitrous acid by means of vitriolic acid, or of some vitriolic salt. For this purpose the nitrous acid must be well saturated with mercury: for if it contains any unsaturated acid, no turbith mineral will appear upon adding either vitriolic salts or pure vitriolic acid. Hence mistakes may be committed in making experiments to discover the presence of vitriolic acid by means of a solution of mercury, as is frequently done.

We ought also to observe, that turbith mineral becomes yellow only by being deprived of the adhering vitriolic acid, and that it remains white till it has been washed with a large quantity of water; in general, the more perfectly it is deprived of acid, the deeper yellow color it acquires.

Turbith mineral has been formerly celebrated for the cure of the venereal disease, but it is now little used, because preferable mercurial remedies have been discovered. *See* ACID (VITRIOLIC), *and* MERCURY.

DCCVII. TURPENTINE. (*l*)

(*l*) TURPENTINE is a resinous juice extracted from several trees. Sixteen ounces of Venice turpentine being distilled with water, yielded four ounces and three drams of essential oil; and the same quantity distilled without water, yielded with the heat of a water-bath, two ounces only. When turpentine is distilled or boiled with water till it becomes solid, it appears yellowish; when the process is further continued, it acquires a

DCCVIII. T U T E N A G. (*m*)

a reddish brown color. In the first state it is called boiled turpentine, and in the second, colophony or common resin. On distilling sixteen ounces in a retort with an open fire encreased by degrees, we obtain, first, four ounces of a limpid colorless oil; then two ounces and two drams of a thicker yellow oil; and lastly, two ounces and a dram of a dark-brownish red empyreumatic oil, of the consistence of a balsam, and commonly distinguished by that name.

The *essential oil* commonly called *spirit of turpentine* cannot without singular difficulty be dissolved in spirit of wine, though turpentine itself is easily soluble in that spirit. One part of the oil may be dissolved in seven parts of rectified spirit of wine; but on standing a while, the greatest part of the oil separates and falls to the bottom. *Neuman*.

(*m*) TUTENAG. This name is given in India to the semi metal *zinc*. It is also sometimes applied to denote a white metallic compound brought from China, called also *Chinese copper*, the art of making which is not known in Europe. It is the best imitation of silver which has been made. It is very tough, strong, malleable, may be easily cast, hammered and polished; and the better kinds of it, when well manufactured, are very white, and not more disposed to tarnish than silver is.

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DCCIX. VALERIAN. (n)

DCCX. VENUS is the name of a planet, which chemifts have alfo applied to fignify copper.

DCCXI. VERDIGRISE. Verdigrife is copper corroded and reduced to a very beautiful green ruft, by a vinous acid. This matter, which is very ufeful to painters, is conveniently manufactured at Montpellier; the wines of Languedoc, of which that city is the capital, being very proper for this preparation.

The following procefs for making verdigrife, is defcribed by Mr. Monet of the Royal Society of Montpellier, and is publifhed among the Memoirs of the Academy for the years 1750 and 1753.

Vine-ftalks well dried in the fun are fteeped during eight days in ftrong wine, and afterwards drained. They are then put into earthen pots, and upon them wine is poured. The pots are carefully covered. The wine undergoes the acetous fermentation, which in fummer is finifhed in feven or eight days, but requires a longer time in winter, although this operation is always performed in cellars. When the fermentation is fufficiently advanced, which may be known by obferving the inner furface of the lids of the pots, which during the progrefs of the fermentation is continually wetted by the moifture of the rifing vapors, the ftalks are then to be taken out of the pots. Thefe ftalks are by this method impregnated with all the acid of the wine, and the remaining

(n) VALERIAN. An ounce of the dry root of valerian yielded with rectified fpirit of wine three drams and fix grains of refinous extract, and the fame quantity with water yielded four drams and twenty-one grains. The diftilled fpirit is flightly, and the diftilled water is ftrongly impregnated with the fmell of the valerian, but no feparable oil is obtained. The moft active preparation is the fpirituous extract, which contains all the ufeful matter of the root. *Neuman.*

liquor

liquor is but a very weak vinegar. The ſtalks are to be drained during ſome time in baſkets, and layers of them are to be put into earthen pots with plates of Swediſh copper, ſo diſpoſed that each plate ſhall reſt upon and be covered with layers of ſtalks. The pots are to be covered with lids, and the copper is thus left expoſed to the action of the vinegar, during three or four days or more, in which time the plates become covered with verdigriſe. The plates are then to be taken out of the pots, and left in the cellar three or four days; at the end of which time they are to be moiſtened with water, or with the weak vinegar above-mentioned, and left to dry. When this moiſtening and drying of the plates has been thrice repeated, the verdigriſe will be found to have conſiderably encreaſed in quantity, and it may then be ſcraped off for ſale.

A ſolution or eroſion of copper, and conſequently a verdigriſe, may be prepared by employing ordinary vinegar, inſtead of wine, as is directed in the above proceſs. But it would not have the unctuoſity of ordinary verdigriſe, which quality is neceſſary in painting. Good verdigriſe muſt be prepared by means of a vinous acid, or ſolvent, half acid, and half ſpirituous. Accordingly, the ſucceſs of the operation depends chiefly on the degree of fermentation to which the wine employed has been carried: for this fermentation muſt not have been ſo far advanced that no ſenſibly vinous or ſpirituous part remained in the liquor.

Verdigriſe is uſed for painting, as it furniſhes a fine green color, when mixed with oil. It enters alſo as an ingredient into ſeveral plaiſters and ointments. In Chemiſtry, verdgriſe is uſed for the extraction of radical vinegar, and for the preparation of *cryſtals of verdigriſe*, or *of Venus*. *See* CRYSTALS *of* VENUS, COPPER, *and* VINEGAR.

DCCXII. VERDITER (*o*).

DCCXIII. VESSELS (CHEMICAL) *and* UTENSILS.

We have ſhewn at the article LABORATORY, how a chemical laboratory ought to be diſpoſed, and the principal utenſils with which it ought to be furniſhed. At the article FURNACES, we have mentioned whatever is eſſential to be known concerning thoſe inſtruments. Laſtly, we have deſcribed under each particular name, the principal veſſels employed in chemical operations. Nothing therefore remains but to make here a kind of enumeration, uſeful to thoſe who would furniſh a laboratory; which enumeration may be conſidered as a compleat ſupplement to that which is given at the article LABORATORY.

(*o*) VERDITER is a blue pigment obtained by adding chalk or whiting to the ſolution of copper in aqua fortis. It is prepared by refiners of ſilver, who employ for this purpoſe the ſolution of copper, which they obtain, in the proceſs of parting, by precipitating ſilver from aqua fortis with plates of copper. *See* PARTING. It is ſaid that a fine coloured verditer cannot be obtained from a ſolution of copper prepared by diſſolving directly that metal in aqua fortis; and that the ſilver is neceſſary. We know that it is actually made by the refiners only. Dr. Merret ſays that it is prepared in the following manner: a quantity of whiting is put into a tub, and upon this the ſolution of copper is poured. This mixture is to be ſtirred every day for ſome hours together till the liquor loſes its color. The liquor is then to be poured off, and more ſolution of copper is to be added. This is to be repeated till the whiting has acquired the proper color. Then it is to be ſpread on large pieces of chalk, and dried in the ſun.

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The ancient chemiſts, and eſpecially the alchemiſts, have invented veſſels of many various kinds and whimſical ſhapes, ſuited to their ſeveral operations. But now the number and variety of thoſe veſſels are much diminiſhed, either becauſe modern chemiſts have not ſo much patience for ſuch tedious and perplexed operations as the alchemiſts had, or becauſe they have found that their operations can be performed with veſſels of a ſimpler form, and leſs various. Accordingly the veſſels required in a laboratory are few and ſimple, which is certainly an advantage. The chief of theſe veſſels are,

Copper Alembics, with their *refrigeraries*, *worms*, and *receivers*. *See all theſe words, and* PLATE I.

Alembics of Glaſs, of *Stone*, and *Earthen-Ware*, of different ſizes, with their *receivers*, which are matraſſes with longer or ſhorter necks. *See* PLATE I.

Adopters, which are ſmall receivers with two necks, the uſe of which to encreaſe the diſtance of the receiver from the diſtilling veſſel and the furnace.

Aludels of Earthen Ware. See PLATE I.

A Balance. See this word.

Balloons, which are matraſſes with large bellies and ſhort necks. They are uſed as receivers. *See* BALLOONS.

Bottles of all kinds and ſizes. A great number of theſe is required in laboratories, to contain the different liquors, and ſubſtances that are volatile, deliqueſcent, or corroſive. The moſt neceſſary of theſe are large glaſs bottles containing three, four, ſix pints, or more, of any form, for containing thoſe matters that are uſed in large quantities. *Cryſtal-glaſs Bottles* with glaſs ſtopples, to contain all volatile or corroſive liquors. The ſmall bottles or *Phials* are very convenient, and may be uſed as matraſſes in many ſmall operations. *See* MATRASS.

Glaſs Jars are cylindrical veſſels uſeful for containing many dry and not volatile ſubſtances. Their mouths are generally cloſed with cork or with paper. Large jars are convenient for the mixing of liquors, for precipitations, &c. A great number of theſe is required of different ſizes.

Baſons of metal. Theſe are uſeful for evaporations. They are generally of copper; but as this metal is very liable to be corroded by ſaline matters, a ſilver baſon is very convenient.

Capſules, or *Diſhes* of glaſs, of ſtone-ware, and of cryſtal-glaſs, which are the beſt of any. Theſe are uſed in the evaporations of corroſive matter capable of acting upon metals. Some alſo are made of crucible-earth, and of plate iron, which are employed for containing the ſand of ſand-baths.

The *Cone*. This is a caſt-iron veſſel of the form of a hollow cone, to the point of which is fixed a pedeſtal, that it may ſtand firmly, with its point turned downwards. The uſe of this cone is to receive metallic matters melted with other ſubſtances, all which being poured into it, the metallic parts of the mixture ſink by their weight to the point of the inverted cone, and are there collected in form of a regulus. The cone ought to be heated, and greaſed with tallow, before the melted matters are poured into it.

Retorts. See that word.

Crucibles are kinds of earthen pots of a cylindrical, conical, or triangular figure, uſed for fuſions of all kinds. They ought to be covered with lids. *See* POTTERY.

Glaſs

Glaſs Funnels. Theſe ought to be of various ſizes; and are neceſſary for ſmall filtrations, and for the pouring of liquors into bottles.

Ingot-moulds are iron veſſels of a certain thickneſs, of the form of hollow ſemi-cylinders, to which a handle is annexed. The ſurface of their ſemi-cylindrical cavities ought to be very ſmooth. They are of various ſizes. The uſe of theſe veſſels is to receive melted metals into their cavities, the form of which is given to the metals, which are then called *ingots*. We ought always to heat and to greaſe theſe moulds before the melted metal is poured into them. *See* PLATE I. *Fig.* 11.

Mortars. See that word.

Matraſſes are long-necked bottles. Some of theſe have round, and ſome flat bottoms. Some are ſhaped like an egg, and thence are called *philoſophic eggs*. Matraſſes are uſed for *ſolutions and digeſtions.*

Muffles. Theſe veſſels, which ought to be made of crucible earth, have the form of a hollow cylinder divided in the direction of its axis, and cloſed on all ſides, excepting its front. This veſſel repreſents an oblong arch or vault, the hinder part of which is cloſed by a ſemicircular plane, and the lower part or floor of which is a rectangular plane. It is a little oven that is placed horizontally in eſſay and enamelling furnaces, ſo that its open ſide correſponds with the door of the fire-place of the furnace. Under this arched oven ſmall cupels or crucibles are placed; and the ſubſtances contained are thus expoſed to heat without contact of fuel, ſmoke, or aſhes. *See* FURNACE (ESSAY); PLATE I. *Fig.* 9, and PLATE II. *Fig* 1.

Pelicans. See that word, and PLATE I. *Fig.* 6.

Receivers. See that word, and PLATES I. *and* II.

Circulatory Veſſels. Two matraſſes are ſo called, into the largeſt of which the matter to be operated upon is to be introduced, and the neck of the ſmaller matraſs is to be fitted into the neck of the former, ſo as to be a kind of ſtopple to it. The joining is to be cloſed with a lute ſuitable to the vapors intended to circulate. By means of this apparatus, one or more ſubſtances may be digeſted during a long time without any evaporation, becauſe the vapors which riſe are condenſed in the ſmall matraſs that ſerves as a ſtopple, and continually fall back upon the matter in the great matraſs. It is, as we ſee, a very ſimple apparatus, which produces the ſame effect as the pelican.

Subliming Veſſels. This name was formerly given to a long-necked matraſs, which being covered with a capital, formed a kind of alembic. It was employed in the diſtillation and rectification of very volatile ſubſtances; but ſince we have found that the length of the neck of an alembic is quite uſeleſs, theſe have been quite abandoned. Accordingly, the true ſubliming veſſels are thoſe that are actually employed in ſublimations. *See* ALEMBICS, ALUDELS, MATRASS, *and* SUBLIMATION.

DCCXIV. V I N E G A R. Vinegar is a vegetable ſpirituous acid, produced by the ſecond degree of fermentation, or by that fermentation which ſucceeds the ſpirituous, and is called the *acid* or *acetous fermentation.*

From this definition it appears, that wine only or vinous liquors can be changed into true vinegar. Every liquor which has completely undergone the ſpirituous fermentation, is ſpontaneouſly and neceſſarily diſpoſed to the acid fermentation. Accordingly every wine does continually tend to become vinegar,

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and actually is changed into vinegar, ſooner or later, according to circumſtances; unleſs this change be prevented by ſome obſtacle to fermentation in general. Vinegar may therefore be made not only from wine of grapes, but alſo from cyder, beer, and, in a word, from all other wines. But as the wine of grapes is preferable for this purpoſe, we ſhall deſcribe the method of converting it into vinegar.

As vinegar is produced by a fermentation, its qualities depend much on the method of exciting and of conducting that fermentation. The wine which is generally converted into vinegar, and which for its cheapneſs is generally employed for this purpoſe, is ſuch as has already become ſour; although the better and the more ſpirituous the wine is, and alſo the more of the vinous ſpirit that can be retained in the vinegar, the better and ſtronger this will be. Beccher ſays, in his *Phyſica Subterranea*, that having digeſted wine in order to convert it into vinegar in a bottle hermetically ſealed, he found, that although a longer than the ordinary time was required, the vinegar produced was much ſtronger then when free air is admitted. Mr. Cartheuſer alſo affirms, that the ſtrength of vinegar may be much encreaſed by adding ſome aqua vitæ to the wine before it is expoſed to the acetous fermentation.

Different methods are practiſed by manufacturers for making vinegar, who are generally believed to be poſſeſſed of ſome ſecret for that purpoſe. Nevertheleſs no more ſeems requiſite in the preparation of good vinegar, than to employ good wine, and to conduct the fermentation in the moſt advantageous method; in the ſame manner as good wine can only be made from good muſt, and by a well conducted fermentation. The principal part of theſe operations is performed by nature.

The method of making vinegar conſiſts in mixing the wine to be fermented with its dregs, and its tartar, and in expoſing this liquor to a heat of about eighteen or twenty degrees. This fermentation ſeems to require more heat than the ſpirituous. It alſo excites more heat and tumult; and although it ought to be allowed to proceed briſkly, yet it is neceſſary from time to time to check it.

Boerhaave deſcribes, in his Elements of Chemiſtry, the following proceſs, which ſeems to be well contrived, for the making of vinegar.

Take two large oaken vats or hogſheads, and in each of theſe place a wooden grate or hurdle, at the diſtance of a foot from the bottom. Set the veſſel upright, and on the grate place a moderately cloſe layer of green twigs, or freſh cuttings of the vine. Then fill up the veſſel with the footſtalks of grapes, commonly called the *rape*, to within a foot of the top of the veſſel, which muſt be left quite open.

Having thus prepared the two veſſels, pour into them the wine to be converted into vinegar, ſo as to fill one of them quite up, and the other but half full. Leave them thus for twenty-four hours, and then fill up the half-filled veſſel with liquor from that which is quite full, and which will now in its turn be left only half-full. Four-and-twenty hours afterwards repeat the ſame operation, and thus go on, keeping the veſſels alternately full and half-full during every twenty-four hours, till the vinegar be made. On the ſecond or third day there will ariſe, in the half-filled veſſel, a fermentative motion, accompanied with a ſenſible heat, which will gradually increaſe from day to day. On

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the contrary, the fermenting motion is almoſt imperceptible in the full veſſel, and as the two veſſels are alternately full and half full, the fermentation is by that means, in ſome meaſure, interrupted, and is only renewed every other day in each veſſel.

When this motion appears to have entirely ceaſed, even in the half-filled veſſel, it is a ſign that the fermentation is finiſhed; and therefore the vinegar is then to be put into caſks cloſe ſtopped, and kept in a cool place.

A greater or leſs degree of warmth accelerates or checks this, as well as the ſpirituous fermentation. In France it is finiſhed in about fifteen days, during the ſummer; but if the heat of the air be very great, and exceed the twenty-fifth degree of Mr. Reaumur's Thermometer, the half-filled veſſel muſt be filled up every twelve hours; becauſe if the fermentation be not ſo checked in that time, it will become violent, and the liquor will be ſo heated, that many of the ſpirituous parts, on which the ſtrength of the vinegar depends, will be diſſipated; ſo that nothing will remain, after the fermentation, but a vapid liquor, ſour indeed, but effete. The better to prevent the diſſipation of the ſpirituous parts, it is a proper and uſual precaution to cloſe the mouth of the half-filled veſſel, in which the liquor ferments, with a cover made alſo of oak-wood. As to the full veſſel, it is always left open, that the air may act freely on the liquor it contains: for it is not liable to the ſame inconveniencies, becauſe it ferments but very ſlowly.

In the *Dictionnaire Portatif des Arts et Metiers*, another method is deſcribed, by which a very good vinegar is commonly made at Paris from the lees of wine. For this purpoſe all the wine contained in the lees is preſſed out, and put into large caſks, the bung-holes of which are left open. Theſe caſks are put into a hot place; and if the fermentation proceeds too faſt, it muſt be checked by adding more freſh wine. This proceſs is very ſimilar to the foregoing.

The appearances which accompany the acetous fermentation reſemble much thoſe that occur in the ſpirituous fermentation. In both fermentations, an inteſtine motion, a ſwelling, a hiſſing noiſe, and an ebullition, may be perceived. There are nevertheleſs eſſential differences between them. Beſides that the products of the vinous and acetous fermentations differ exceedingly, the heat produced by the former is ſcarcely ſenſible, while that produced by the latter is conſiderable. Secondly, we have reaſon to believe, that the vapour which exhales from vinegar during fermentation is not noxious, as the vapor of fermenting wine is; at leaſt, it has not been obſerved to produce ſuch bad effects. On the contrary, as the acid of vinegar more and more diſengages or unfolds itſelf, it ſeems to acquire more power to bind and retain the inflammable principle, which is the truly dangerous part of theſe vapors. Laſtly, vinegar does not depoſit tartar as wine does, even although it has been made with wine that had not depoſited its tartar. But the ſediment of vinegar is a viſcid, oily, and very putreſcent matter. The grape-ſtalks uſed in the making of vinegar, to promote and encreaſe the fermentation, are covered over with this matter during the operation. They are generally waſhed clean, and carefully preſerved, to promote the fermentation of more vinegar; becauſe the acid with which they are ſoaked acts powerfully as a leaven or ferment. The caſks alſo which have been uſed for the preparation of vinegar are to be cleanſed

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from the above-mentioned viscid matter, and kept for the same use, as they are rendered fitter than new casks for the preparation of vinegar.

When the acetous fermentation is finished, the nature and the character of the liquor that has undergone it are totally changed. Wine has a taste and smell, partly spirituous, somewhat acid; but in good wine the spirit so much prevails over the acid, that the latter is scarcely perceptible. The taste and smell of vinegar also is partly acid and partly spirituous; but the former quality so entirely prevails, that the latter is almost totally concealed.

We cannot form any very clear and distinct knowledge of the manner in which Nature performs these changes in fermenting liquors. The properties of wine and vinegar prove, that the acetous fermentation unfolds in a very singular manner the acid parts of wine, and intimately combines them with the inflammable spirit. Hence, by changing wine into vinegar, its ardent spirit is so covered by the large quantity of acid, that it is no longer perceptible; that it now cannot affect the head and intoxicate; and that if it be distilled, the first liquor that rises with a heat less than that of boiling water is not an ardent spirit, as when wine is distilled, unless the vinegar be too new, and the acetous fermentation has not been completely finished; in which case the vinegar yields a little ardent spirit: but when old vinegar is distilled, the liquor that rises first is a slightly acid phlegm, which contains the most volatile, the most odoriferous, and the most spirituous part of the vinegar.

The acid of vinegar is employed in many chemical and pharmaceutical preparations, for which not common vinegar, but the acid spirituous part of vinegar that is obtained by distillation, called *distilled vinegar*, is chiefly employed.

The process of distilling vinegar is very simple. A quantity of good ordinary vinegar is put into a large cucurbit or still, which ought to be made of stone-ware, and not of metal, as the acid of vinegar is capable of acting upon most metals. This cucurbit is sunk in a deep furnace, so that five or six fingers breadth only near its neck appears. The neck is to be carefully luted with clay all round the furnace, that the capital may not be heated too much. A capital and a glass receiver are then to be fitted, and the distillation is to be begun, with a very gentle heat. The acid spirituous liquor passes by drops into the receiver. This liquor is white, transparent, penetrating, somewhat empyreumatic, and disengaged from an acid, but not spirituous substance, and also from an extractive saponaceous matter, both which are contained in ordinary vinegar. These latter substances remain in the still with the coloring matter, and form together an extremely acid extract of vinegar. This residuum contains also some tartar, and by incineration yields much fixed alkali, as all matters belonging to vines, grapes, or wine, do.

We should be much mistaken if we believed that the acid spirituous portion of the vinegar that rises in this distillation, is a stronger acid than the vinegar itself. Vinegar is not distilled with an intention to concentrate it, but only to disengage it, as we have said, from its extractive part. The acid which this part contains is not, properly speaking, vinegar, but is oily, not spirituous, less volatile than the former, or even than water. Accordingly, the acid obtained in this distillation, when well conducted, is more spirituous and also more watery than the acid of the residuum.

Chemists

Chemiſts have attempted different methods of concentrating diſtilled vinegar. Stahl has taught us the beſt method for depriving it of its water without any alteration. This method conſiſts in expoſing it to a cold ſufficiently intenſe to freeze its watery part, which is afterwards ſeparated in lumps of ice from the more acid part. Thus the acid of vinegar may be conſiderably concentrated. *See the* CONCENTRATION *of* VINEGAR *by* FROST.

The acid of vinegar may be more effectually concentrated by combining it with alkalis, earths, and metals, as any other acid may. Thus by drying perfectly neutral acetous ſalts with fixed baſes, and afterwards by decompoſing them, either by the mere action of the fire, or by means of concentrated vitriolic acid, we obtain the ſtongeſt acetous acid that can be produced. This acid is called *radical vinegar*. *See* SPIRIT *of* VENUS.

The acid of vinegar diſſolves all ſubſtances upon which other acids can act, and forms with them neutral ſalts, ſome of which have particular names, but which all might be called *acetous ſalts*.

With calcareous earth this acid forms ſalts that in cryſtallizing ſhoot into ſilky ramifications and vegetations. Theſe ſalts are named from their earthy baſes, *ſalt of chalk*, *ſalt of crabs-eyes*, &c.

With fixed vegetable alkali it forms a very pungent and very deliqueſcent ſalt, called *regenerated tartar*, or *terra foliata tartari*. *See* TERRA FOLIATA.

With fixed mineral alkali it forms a neutral cryſtallizable ſalt.

With volatile alkali it forms *an acetous ammoniacal ſalt*, called *ſpirit of Mindererus*.

All the combinations of the acetous acid with metallic ſubſtances have not been yet examined. The combinations of this acid with lead and with copper are beſt known, becauſe they furniſh ſeveral preparations uſed in painting, and ſome other arts. This acid united with copper forms *verdigriſe* and *cryſtals of Venus*; and with lead forms *ceruſs*, and *ſalt or ſugar of lead*. *See theſe ſeveral articles*. The vinegar in which lead is diſſolved is called *vinegar of lead*, and is ſometimes uſed as a coſmetic, for repelling cutaneous eruptions. But this coſmetic ought not to be employed but under the direction of a prudent phyſician, as it may occaſion a dangerous tranſlation of the morbid humour to other parts.

Mercury diſſolved firſt by nitrous acid, and afterwards precipitated by fixed alkali, is quickly ſoluble in vinegar, with which it forms a mercurial acetous ſalt. The cryſtals of this ſalt are ſhining ſilver-like plates, not very ſoluble in water. *See* MERCURY.

Vinegar very much concentrated, as the rectified ſpirit of Venus, or radical vinegar, being diſtilled with equal parts of highly rectified ſpirit of wine, furniſhes a liquor which has all the eſſential characters of ether, or rather is a true ether, called *acetous ether*. The diſcovery of this ether was lately made by the Count de Lauraguais. *See* ETHER (ACETOUS).

Vinegar being an oily, ſpirituous, vegetable acid is much weaker than mineral acids, which are leſs compounded. Accordingly all acetous neutral ſalts may be decompoſed by any mineral acids, excepting the vitriolic acid when very much ſulphurated, which cannot be conſidered as a pure acid.

According to Mr. Gellert's table, the affinities of the acetous acid are in the following order: Inflammable principle, zinc, iron, copper, lead, and biſmuth.

Gold, ſilver, tin, and mercury, are marked in this table as incapable of uniting with this acid.

Vinegar is very uſeful, not only in ordinary life as an agreeable ſeaſoning for many kinds of food, but alſo in medicine, in chemiſtry, and in ſeveral arts.

This acid is in general antiſeptic, and is conſidered as inciſive and aperitive. It is uſed as a vehicle in many preparations which poſſeſs theſe qualities. Thus *ſimple oxymel* is a ſyrup made of honey and vinegar. Such alſo are *oxymel of ſquills*, and ſeveral other compound vinegars for the uſe not only of medicine, but alſo of the toilette; receipts for all which are found in diſpenſatories. A very important medicinal virtue has been attributed to vinegar, namely, that of curing the canine madneſs. Mr. Buchoz, in a work entitled, *An Hiſtorical Treatiſe of Plants growing in Lorraine and the Three Biſhopricks*, affirms, that ſeveral ſucceſsful trials have aſcertained the efficacy of vinegar againſt the ill effects ariſing from the bite of mad dogs, when it is given in the quantity of a pound each day, divided into three doſes; one to be taken in the morning, another at noon, and the third in the evening. The diſcovery of this quality of vinegar was made accidentally at Udina, in Trioul, a province belonging to Venice, by an inhabitant of that town, who having been ſeized with canine madneſs, was cured by drinking a glaſs of vinegar by miſtake, inſtead of ſome medicine that had been prepared for him.

We have already mentioned the uſe of vinegar in ſeveral chemical preparations, particularly of ceruſs and of verdigriſe.

DCCXV. VINEGAR (DISTILLED). This is the ſpirituous acid of vinegar obtained by diſtillation. *See the preceding article.*

DCCXVI. VINEGAR (RADICAL). *See* Spirit *of* Venus.

DCCXVII. VINEGAR *of* LEAD. Is a ſolution of lead or of ceruſs in diſtilled vinegar. *See the articles* Lead *and* Vinegar.

DCCXVIII. VITRIFICATION. Vitrification is one of the moſt curious and moſt important operations in chemiſtry. The product of this operation is Glaſs; a matter which, when well made, is valuable for its great hardneſs, beauty, and perfect tranſparency. Theſe principal and eſſential qualities of glaſs render it very extenſively uſeful in ordinary life, in natural philoſophy, in chemiſtry, and in many arts. Almoſt any form may be given to glaſs, and all kinds of veſſels and utenſils may be formed of it, which are capable of reſiſting the moſt powerful corroſives and ſolvents. Glaſs is capable of receiving and preſerving the fineſt poliſh. Its properties of tranſmitting and refracting the rays of light, and of reflecting theſe rays when one of its ſurfaces is covered with a metallic coat, render it very uſeful for conſtructing mirrors, teleſcopes, microſcopes, and all kinds of optical glaſſes; for collecting, ſeparating, and decompoſing the rays of light; and for exhibiting many wonderful catoptrical and dioptrical appearances and experiments. If to theſe admirable properties we add that of imitating the many brilliant precious ſtones, opake or tranſparent, we ſhall eaſily be convinced that perfect glaſs is one of the moſt beautiful and excellent productions of human induſtry.

The art of making glaſs is dependant on chemiſtry in all its parts. In its principles it is ſimple, but extenſive in its detail, and difficult in its practice. The extent of this art does not permit us to enter into the particulars, or into

its ſeveral branches. In this article we ſhall only endeavor to explain the chemical principles upon which the art depends, and which may direct experimental philoſophers as well as intelligent artiſts in their reſearches to improve it.

Perfect glaſs, or the moſt beautiful factitious cryſtal, is perfectly ſimilar in appearance to the whiteſt and moſt tranſparent natural vitrifiable ſtones. The only ſenſible difference between theſe natural and artificial productions is, that the latter are much leſs hard and more fuſible than natural cryſtal, or any other vitrifiable ſtone. In fact, pure glaſs or artificial cryſtal is eſſentially of the ſame nature as vitrifiable ſtones; or we may rather ſay, that it is vitrifiable earth itſelf rendered more fuſible only by certain additions, as we ſhall ſoon ſhew.

The moſt ſimple and elementary of all earths, called by chemiſts *vitrifiable earth*, forms the hardeſt and moſt tranſparent of all natural bodies, when its integrant parts are united together in a due ſtate of aggregation: but the parts of vitrifiable earth cannot form this aggregation, unleſs they have been previouſly ſo much ſeparated from each other, that they poſſeſs a mobility which enables them to unite together according to their natural tendency: the integrant parts of elementary earth may acquire this mobility by two methods; namely, by the interpoſition of the parts of water, or of thoſe of fire.

Almoſt all the vitrifiable ſtones that we know, as diamonds, rock-cryſtal, and other hard tranſparent ſtones, appear to have been once diſperſed in infinitely ſmall molecules through much water, from which they have afterwards been depoſited, and then have united together and formed the very hard tranſparent maſſes which we now ſee. The regular and uniform cryſtallization of theſe precious ſtones is an evident proof of this truth.

Poſſibly ſome of theſe ſtones may have been formed by fire, and by a true fuſion. Perhaps even this terreſtrial globe has been once, as Mr. de Buffon thinks, one ſphere of melted glaſs, or one immenſe diamond, the outer cruſt of which only has been changed by the elements, while the interior parts ſtill remain in their vitrified ſtate (*p*): but we certainly know, that of the two abovementioned methods by which pure ſolid maſſes of vitrifiable earth may be formed, that of the diviſion and elaboration by water cannot be practiſed by human art, on account of the many ages required for the operation.

By the ſecond method, namely, *fuſion*, the time required for which is better adapted to the ſhortneſs of our lives, we certainly might, with a ſufficient degree of heat, melt vitrifiable earth, and all other kinds of earths; ſince theſe, when ſufficiently purified, are reduced to the nature of vitrifiable earth; and we might convert theſe earths into maſſes of cryſtal, or of hard tranſparent ſtones,

(*p*) Mr. Buffon conjectures, that the earth, as alſo the other planets, might have been parts knocked off from the ſun by a comet falling upon its ſurface; that they received from the impulſe of the comet their progreſſive motion; and alſo, by the obliquity of the ſtroke, their motion round their own axes; that the earth was then in a vitrified and fluid ſtate; and that a vapor exhaled from its ſurface by the violent heat, the groſſer parts of which, being afterwards condenſed, formed water, and the leſs denſe remaining ſuſpended formed air. We have not heard that many philoſophers have adopted this theory of the formation of the planets,

as perfect as the natural precious ſtones. In a word, nothing but a heat ſufficiently intenſe is required to melt any earthy matter, and to convert it into a diamond, as brilliant and as hard as the moſt perfect natural diamonds: but here a great, and hitherto unſurmountable difficulty occurs, namely, to produce a heat ſufficiently intenſe to melt the moſt pure and ſimple vitrifiable earth; for the moſt violent heat that art has ever produced is inſufficient to melt even many of the common impure earths and ſtones, and is therefore much leſs capable of melting that earth, which, becauſe it is the ſimpleſt and pureſt, is alſo the moſt unfuſible of all natural bodies. *See* EARTH.

Hence we conclude, that although we know by what means the parts of the pureſt earthy principle may be ſo united as to form bodies ſimilar to the natural precious ſtones, yet we cannot poſſibly put theſe means in execution: but if we cannot artificially produce ſolid maſſes of pure earth exactly ſimilar in all their properties to the natural precious ſtones, we can however very well imitate theſe beautiful natural productions, not in their hardneſs and unfuſibility, but in their tranſparency and luſtre; that is, in their moſt obvious and ſtriking qualities, by means of compoſitions of glaſs or factitious cryſtal. The ſolution of this problem is founded on the following principles.

Firſt, pure and elementary earth, which makes the principal baſis of all vitrifications, and therefore called vitrifiable earth, is indeed unfuſible with regard to us: but we know, that certain very fuſible ſubſtances are capable of uniting intimately with this earth, and of communicating to it ſome of their fuſibility; ſo that by their means we may reduce it to a perfect fuſion.

Secondly, the ſubſtances capable of acting upon the earthy principle are the inflammable principle or phlogiſton, and ſeveral ſaline matters: but we may remark, that as theſe ſubſtances do only act as fluxes by uniting intimately with the vitrifiable earth, and while they themſelves make part of the glaſs; and alſo, as the integrant parts of theſe fluxes are not capable of forming either with each other, or with the parts of vitrifiable earth, ſo ſtrong an adheſion as that which can be formed between the parts of the pure vitrifiable earth; it follows, that all factitious cryſtal muſt be much leſs hard than natural cryſtals, or other hard ſtones; ſince theſe contain only pure vitrifiable earth.

Thirdly, in conſequence of the principle, that all compound bodies partake of the properties of their component parts, factitious cryſtals ought to partake ſo much more of the properties of inflammable and ſaline matters, and ought to be removed ſo much more from thoſe of pure vitrifiable ſtones, as they contain a larger quantity of thoſe matters. Accordingly we find, that the ſmaller quantity of flux that is contained in glaſs, the greater hardneſs, luſtre, and reſemblance to natural ſtones it has, provided the fuſion has been compleat. Thus glaſs is ſo much more perfect, as it poſſeſſes more of the properties of vitrifiable earth.

Theſe principles, which are inconteſtable, being once underſtood, are eaſily applicable to the art of making glaſs, as we ſhall ſhew: ſince, if we could produce a fire ſufficiently intenſe, and had furnaces and veſſels capable of ſuſtaining it, we ſhould make glaſs equal to the precious ſtones; it is therefore evident, that the moſt important object in vitrification is to have furnaces capable of producing the greateſt heat, and pots or crucibles capable of reſiſt-

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ing, during a long time, this heat, and alſo the action of the vitreſcent matter that they contain. At the articles of this Dictionary, Clay and Pottery, may be ſeen what are the beſt earths, or mixtures of earths, for the conſtruction of furnaces, and of pots or crucibles. We ſhall here only repeat, that theſe pots ought to be made entirely of the moſt refractory and pureſt clay, well waſhed and cleanſed from all ſandy, ferruginous, and pyritous matters, and mixed with a certain proportion of the ſame clay baked, and pounded not very finely. The quantity of baked clay that ought to be mixed with the crude clay, to prevent the pots from cracking when dried, or when expoſed to violent heat, is not abſolutely determined, but varies in different glaſs-houſes, according as the crude clay employed be more or leſs fat, as it is called: but Mr. D'Antic, Doctor of Phyſic, a very able chemiſt, and particularly converſant about every thing relating to the theory and practice of glaſs-making, in an excellent Memoir upon this ſubject, propoſes a very good method of aſcertaining the quantity of burnt clay that ought to be mixed with crude clay in the compoſition for pots and furnaces. This method conſiſts in mixing the burnt and crude clay in different proportions, and in forming cakes of theſe ſeveral mixtures, each of which is one inch in thickneſs, and four inches in each of the other two dimenſions. When theſe cakes have been ſufficiently and very ſlowly dried, and are expoſed to a violent heat, till they become as hard, and contract as much in their dimenſions as they can, they are to be then examined; and the cake which has ſuffered a diminution of its bulk equal only to an eighteenth part is made of the beſt proportions. According to the ſame author, moſt clays require that the proportion of the burnt ſhould be to the freſh as four to five.

The ovens and furnaces are different according to the quantity of materials to be vitrified. For experiments and eſſays, we know none better than the melting furnace deſcribed at the article Furnace, and which muſt be heated with charcoal. In large works wood or foſſil coal are uſed, and the furnaces are ſo conſtructed that the flame of the fuel circulates and burns within very intenſely. As theſe furnaces vary much in different countries and glaſs-houſes, and as a deſcription would not be very intelligible without figures, we ſhall refer the reader to other works in which theſe ſeveral furnaces are deſcribed and repreſented, particularly to the French edition of Neri's Art of Making Glaſs, with Notes by Merret and by Kunckel, and to the above quoted Memoir of Mr. D'Antic. We ſhall here ſay only in general, that theſe furnaces are placed under large and lofty buildings called *halls*; that they are covered with a vaulted roof; and that they have no chimney, but only lateral openings through which the melted glaſs is drawn from the pots. Under theſe openings is built a kind of platform or banquette, on which the pots containing the glaſs ſtand, one of which is oppoſite to each opening. In the middle of the furnace, below the banquette, is a ſpace, a-croſs which iron bars are laid. In this ſpace, which communicates with a large cavity below, called the aſh-hole, the fuel is placed. In theſe furnaces, which have not any chimney, as we have ſaid, the fire is nevertheleſs very intenſe. This intenſe heat is occaſioned by the great capacity of the furnace, by means of which a ſtrong draught of air paſſes continually from the aſh-hole. Beſides, the flame, being vividly agitated by air, and not being drawn out of the furnace by any chimney, circulates in

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every direction within the furnace, and produces a very violent heat. Most glass-house furnaces have also hollow towers that communicate with the cavity of the furnace, and which therefore encrease the capacity of the whole. In these the heat is not nearly so intense as in the furnace. They are employed to contain the *fritt*, or the pieces of manufactured glass that are to be annealed. Such is the general disposition of the furnaces of glass-houses.

The good condition of the pots and furnaces is, as we have observed, the most important and essential matter to be considered in the operations of making glass. Next to that, is the consideration of the kinds and proportion of the fluxes. Of these we may observe two kinds, namely, the inflammable and the saline. As we cannot obtain the pure inflammable principle, we must, when we intend that it should enter into the composition of glass, chuse for this purpose some of the earthy substances with which it is found naturally combined; and these are particularly metallic earths, which are best adapted for conveying phlogiston into vitreous compositions: but all these earths are not equally fit for this purpose. All metals are composed of an earthy matter intimately combined with a sufficient quantity of the inflammable principle to be very fusible, and, at the same time, very opake. Some of these metals, namely, those called *perfect*, are unalterable by fire, and cannot be entirely, or even partly, deprived of phlogiston: but as every metallic substance is incapable of uniting with earthy matters, while it retains its metallic state, therefore no perfect metal can be vitrified. The case is different with those metallic substances, the phlogiston of which may be burnt, or otherwise destroyed. The earths or calxes of most, perhaps of all combustible metals, when not perfectly deprived of all their phlogiston, are capable of being reduced to a vitreous state, by means of their remaining inflammable principle. As they are not then in a metallic state, they can facilitate the fusion of vitrifiable earths, may contract with these an intimate union, and reduce them to a state of perfect vitrification: but these phlogisticated calxes of imperfect metals promote vitrification more or less, according to their particular natures. Some of these, as, for instance, tin, cannot be without great difficulty brought to that precise degree of calcination that is necessary to vitrification; because the heat required for this purpose deprives them of all their phlogiston, and renders them in a high degree refractory. Others, in whatever manner they be calcined, either retain too little phlogiston to be sufficiently fusible, although they still retain enough to give them color; or if they be not calcined so much as to lose their fusibility, they cannot be melted but into opake masses, so nearly in a metallic state that they cannot be united intimately with vitrifiable earths. Such, especially, are the earths of iron and of copper.

Of all metallic earths, that of lead is fittest for vitrification. This metal, which contains a large portion of phlogiston, is quickly deprived of so much of it, that it loses its metallic state, and is easily melted into a transparent vitreous mass; but it has, at the same time, this remarkable property, that when once it has lost as much phlogiston as is necessary to dispose it to vitrification, its calx strongly retains as much of it as is necessary to give to it its greatest degree of vitrescibility; and that it may be sooner dissipated into vapors by the continued action of a very intense fire, than it can be changed into an earth

totally

totally dephlogisticated, and consequently refractory, like the calxes of tin and of regulus of antimony. Besides, the fusible earth of lead is one of these that retain the least color. All these qualities render it preferable to any other metallic earth for the purposes of vitrification. The earth of bismuth, which in the above-mentioned properties resembles the earth of lead, may probably be employed with equal success: but as the calxes of lead are much more common than those of bismuth, the use of this semi metal is not known to manufacturers of glass.

In whatever manner the calx of lead has been prepared, provided it be really in a calcined and not in a metallic state, it may be used in vitrification. Accordingly, the grey calx, or ashes of lead, massicot, red lead, litharge, cerus, and all the precipitates of lead, separated from acids by unmetallic intermediate substances, being mixed with sand or any other vitrifiable stone, and exposed to a sufficient degree of fire, do always promote the fusion of these matters, and form with them glasses more or less hard and transparent, according to the strength of the fire and the proportion of the ingredients.

The earth of lead constantly retains, as we have said, enough of the inflammable principle to preserve its fusibility. When it is exposed singly to the fire, it vitrifies with a very moderate heat. It has more phlogiston than is requisite for its vitrification. The fusibility, fluidity, and activity of this glass of lead, when pure, are so great, that it cannot be contained in any crucible, all which it easily pervades: therefore pure glass of lead is never made. But as the calx of lead has more phlogiston than is required for its own vitrification, it may divide this excess of inflammable principle with any unmetallic earths with which it is mixed, and thus may produce their fusion and perfect vitrification. The glasses formed by a mixture of calx of lead with unmetallic earths have more consistence, hardness, and less fusibility, than pure glass of lead. The proportions of calx of lead and of sand employed in these kinds of glass are from one part to two of calx of lead, to one of sand, or of ground flints.

We may observe upon the subject of glasses that contain no other flux than phlogiston or metallic earths, of lead, or of any other metal, that none of them are perfectly white, but are all more or less colored; because phlogiston is, as chemists know, the principle of colors. Secondly, these glasses have a greater density or specific gravity than any natural crystalline stone, all metallic earths being heavier than any that are not metallic.

Thirdly, metallic glasses are generally somewhat less brittle, are less liable to be broken by the alterations of heat and cold, and have more of a certain smoothness, or, as it were, unctuosity, not easily to be described, than glasses made altogether of unmetallic earths. These properties can only be attributed to the inflammable principle, a pretty considerable quantity of which is united with them. As these latter qualities of glass are valuable, a certain quantity of calx of lead generally enters into the composition of most fine glasses, which are distinguished from ordinary glass by the name *crystal-glass*.

From what we have said concerning the properties of metallic earths in vitrification we may perceive, that the more calx of lead, or other metallic earth, enters into the composition of any glass, the more fusible, soft, colored, and

denſe this glaſs is; and reciprocally. The colors given to glaſs by calxes of lead are ſhades of yellow.

Saline ſubſtances are the ſecond kind of fluxes uſed in vitrification: but all theſe ſubſtances are not equally fit for this purpoſe; not that they are not all very fuſible, but for ſeveral reaſons hereafter to be mentioned.

Firſt, neither the pure and diſengaged acids, nor volatile alkalis, nor ammoniacal ſalts can be employed as fluxes in vitrification, becauſe none of theſe ſaline matters is ſufficiently fixed. Their volatility is ſo great, that they may be totally diſſipated by fire before they could act in any degree upon vitrifiable earth.

Secondly, none of the neutral ſalts with baſis of fixed alkali, containing either vitriolic acid or marine acid, can be employed as fluxes in vitrification. This proceeds, not from their want of fuſibility, or of the neceſſary degree of fixity, but from the union of the acid and the alkali; which is ſo ſtrong, that they cannot act with ſufficient force upon other ſubſtances, and particularly upon vitrifiable earth. The ſaline matters fit for vitrification are, *fixed alkalis*, vegetable and mineral; *nitres* with baſis of fixed alkali; *ſedative ſalt*, and *borax*; *fuſible ſalt of urine*, or rather *phoſphoric acid.*

Of all ſaline matters, fixed alkalis, vegetable and mineral, are moſt frequently uſed in vitrification. Theſe alkalis are fuſible with a moderate heat; they are ſo fixed that they can reſiſt during a ſufficient time the heat of ordinary vitrifications; and they act powerfully upon flints, ſands, and other vitrifiable ſtones. The proportion of alkali to ſand, in order to make good glaſs, is, from one to two parts of the former ingredient, and two parts of the latter.

Nitre produces in vitrification nearly the ſame effects as fixed alkalis, altho' it be a neutral ſalt, the alkali and acid of which are united together nearly as they are in common ſalt, which however does not produce in vitrification ſimilar effects. The remarkable difference in this reſpect betwixt theſe two ſalts, and betwixt the nitre and the vitriolic ſalts, muſt be attributed to the great affinity of nitrous acid to the inflammable principle; which affinity is ſo ſtrong, that when nitre is expoſed to fire in veſſels not perfectly cloſe, the acid quits its alkaline baſis to unite with the phlogiſton of combuſtible matters, even though theſe be not ſenſibly in contact with it. Hence nitre expoſed during a certain time to the action of a ſtrong fire, is gradually alkaliſed, and then becomes capable of diſſolving very effectually vitrifiable earth. This alkaliſation is produced ſo much more eaſily in moſt vitrifications, that the ingredients employed generally contain ſome inflammable matter. Common ſalt cannot be alkaliſed in this manner, becauſe it cannot be decompoſed by the contact of inflammable bodies, and therefore is not uſed in vitrifications: but as vitriolic acid has a ſtrong affinity with phlogiſton, we might be inclined to think, that vitriolic ſalts with baſis of fixed alkali, which alſo are never uſed in vitrification, might perhaps be employed along with ſand or other vitrifiable matters containing a larger proportion of phlogiſton than the ingredients now commonly uſed do: but I do not know that any ſufficiently accurate experiments have been made on this ſubject.

Fixed alkalis or nitre cannot be formed into tranſparent glaſs by being melted ſingly; becauſe theſe ſalts contain too little of the earthy principle; for they form

form true glaſſes when they are mixed with a ſufficient quantity of this principle, as with ſands and other earthy matters: but borax, ſedative ſalt, and the fuſible ſalt of urine, may be melted without any earthy addition, into tranſparent vitreous maſſes; and hence we may conclude, that theſe ſalts contain a larger portion of the earthy principle than nitre or fixed alkali. They nevertheleſs very powerfully promote the vitrification of other ſubſtances. Theſe ſalts are not employed in the manufacture of large quantities of glaſs, becauſe they are too dear. Borax is ſometimes uſed for making ſmall quantities of ſome particular kinds of fine glaſs.

Arſenic may be enumerated among vitrifying fluxes, as it is fuſible and vitreſcible ſingly, and is alſo capable of promoting the fuſion of vitrifiable earths; for which purpoſe it is frequently employed as an ingredient in vitreous compoſitions. As arſenic partakes both of the metallic and ſaline properties, it probably acts in vitrification both as a ſalt and as a metallic earth. The quantity therefore of arſenic neceſſary to promote vitrification, is intermediate betwixt the quantities of calx of lead and of ſaline ſubſtances that are neceſſary for that purpoſe. But we muſt obſerve, that as arſenic is very volatile, a great part of it eſcapes in vapors upon the firſt application of heat, and that the quantity remaining is always uncertain. Arſenic cannot well be employed as the ſole flux for vitrifiable earth. When we intend that a certain quantity of this matter ſhould remain in the compoſition of a glaſs, one of the beſt methods that can be uſed for this purpoſe, is at the ſame time to add nitre to the ingredients of this glaſs; becauſe the arſenic uniting with the alkaline baſis of the nitre forms the neutral arſenical ſalt, in which the arſenic is conſiderably fixed. But as this neutral arſenical ſalt is eaſily decompoſed by contact of phlogiſton, therefore no calx of lead or other ſubſtance containing the inflammable principle ought to be mixed with arſenic in the compoſition of glaſs. I have found by experience that this neutral arſenical ſalt is very difficultly manageable in vitrifications, not only for the reaſon now given, but alſo from the property it has of powerfully corroding and pervading crucibles and pots. In many mixtures I have found that it quitted the vitrifiable earth with which it was mixed, and acted upon the crucible, which it penetrated and diſſolved. Theſe experiments induce me to believe, that arſenic has a greater affinity with clays than with vitrifiable earths; which I propoſe hereafter to aſcertain further.

From Mr. Pott's experiments, chemiſts know, that vitrifiable, calcareous, and argillaceous earths, each of which are ſingly unfuſible, do reciprocally promote the fuſion of each other, when mixed together nearly in equal proportions, and expoſed to a very violent heat; and that from theſe mixtures matters perfectly vitrified are formed. But as we do not know the cauſe of this ſingular fuſibility, we cannot determine whether it is produced by a phlogiſtic or by a ſaline ſubſtance, or perhaps by both.

Glaſſes that contain no other fluxing ingredient than phlogiſtic matters or metallic earths, partake of the properties of theſe metallic earths; and alſo glaſſes that contain only ſaline fluxes partake of the properties of ſalts. The latter, or ſaline glaſſes, when pure and well proportioned are leſs heavy, leſs denſe, harder, whiter, more brilliant, more brittle, than the glaſſes containing calx of lead: and glaſſes containing both ſaline and metallic fluxes do alſo partake of the pro-

perties of both these substances. In general, glasses too saline are soft, and easily susceptible of alteration by the action of air and water; especially those in which alkalis prevail; which latter glasses are also liable to be attacked by acids, as we evidently see from the properties of the vitrified matter that is made with an excess of alkali, for the preparation of *liquor of flints*. Glasses containing too much borax and arsenic, although at first very beautiful, do quickly tarnish and become opake when exposed to air.

From what we have said concerning the properties of fluxes, phlogistic or saline, we may know how to adjust the proportions of these to the sand, or powdered flints, for the various kinds of glass. Thus if we require a glass that is dense, fusible, and not saline, one part and a half of red lead or litharge may be mixed with one part of sand, and fused together. If equal parts of sand and of calx of lead be employed, a glass somewhat less dense and harder will be produced.

If a glass be required of very little density, only saline fluxes must be employed. A glass of this kind may be composed of six parts of salt of tartar, or of potash, or of purified soda, mixed with eight parts of sand or of flints; or of four parts of any of the above-mentioned alkalis, mixed with two parts of nitre or of borax, and eight parts of vitrifiable earth. These glasses must be left long in the fire for the reasons hereafter to be mentioned.

When a crystal-glass is required which shall be of an intermediate quality betwixt the metallic and saline glasses, it may be made from a mixture of one part of the above-mentioned salts, one part of calx of lead, and two parts of sand or other vitrifiable earth. By varying the proportions of these ingredients, many different kinds of glasses may be produced, each of which may be good, if the quantity of each of the fluxes employed be proportionable to its vitrifying power. Several good receipts for glass, and factitious crystal, may be found in *Neri's Art of Making Glass*, with *Notes by Merret and Kunckel*, to which work we refer for many interesting particulars. We shall however observe, that the proportions of the fluxes necessary to produce any required kind of glass cannot be precisely ascertained, for the following reasons.

First, the sands, flints, and other stones commonly employed for making of glass, are not all equally fusible. Thus the quartzose sand obtained by washing an earth found near Nevers, known to manufacturers of glass and of pottery by the name of *sand of Nevers*, may be almost entirely melted when exposed to a good vitrifying heat; and by a moderate heat its grains may be considerably rounded. I know some other hard stones, which in a violent fire are still more fusible, and convertible into an almost transparent glass without addition. The fusibility of these vitrescible stones is caused by some unknown heterogeneous matter united with them. These fusible sands and stones require much less quantity of flux to promote their vitrification, than other sands or vitrifiable stones, which are much purer, and therefore more refractory.

Secondly, although the phlogistic and saline matters employed as fluxes in vitrification are sufficiently fixed to support the degree of fire necessary for the fusion of glass, they are nevertheless far from being so fixed as vitrifiable earth. The fire necessary for the perfect fusion of glass, is even sufficient to evaporate them entirely. Accordingly in glass-houses where the pots are uncovered, a vapor

vapor or ſmoke continually riſes from their ſurface, which is nothing elſe than the ſaline and phlogiſtic fluxes in a ſtate of continual exhalation. Hence the longer glaſs remains melted in the fire, the harder and more difficultly fuſible it becomes, and the more it partakes of the properties of pure vitriſiable earth. Accordingly, even when a very hard glaſs is required, ſuch a quantity of flux ought to be added, as ſhall at firſt promote a perfect fuſion; and this fuſion ought to be continued a long time till a conſiderable quantity of the flux is gradually diſſipated, and till the glaſs has acquired the requiſite degree of hardneſs, provided that the fire be ſufficiently ſtrong to maintain the fuſion notwithſtanding the loſs of flux. From theſe obſervations it appears, that we cannot preciſely aſcertain the proportion of flux to vitriſiable earth, unleſs we knew the fuſibility of the ſand to be employed, and the degree of heat which can be excited in the furnace.

The ſaline fluxes, and eſpecially the fixed alkalis employed in vitrification, are generally rendered impure by a mixture of ſeveral heterogeneous matters, and eſpecially by neutral ſalts not vitrifiable, and by a certain quantity of inflammable principle. In manufactories of bottles and other common glaſs, the alkalis employed are not previouſly purified, but are even mixed with the earth of the aſhes of the burnt plants, which earth is alſo much diſpoſed to vitrification. Accordingly, to make glaſs of this kind, ſand is mixed with common wood-aſhes, ſometimes even with thoſe which have been lixiviated, together with ſome unpurified potaſh, ſoda or kelp; and from this mixture a brown, duſky, not very tranſparent glaſs is produced, which is preferred in common ſale for wine bottles to clearer and more tranſparent glaſs. But when a fine, white, and very tranſparent glaſs is required, the alkali muſt be perfectly purified from all heterogeneous matter, by lixiviation and calcination. *See the article* ALKALI (FIXED).

As a too large quantity of the inflammable principle is the chief cauſe of the colors and of the opacity of glaſs, when a perfectly colorleſs and tranſparent glaſs is required, not only the alkalis muſt be deprived of all their ſuperabundant phlogiſton, but alſo the ſands or flints employed muſt be purified from any of this principle which they may contain. The method uſed for this purpoſe is, by mixing together the due proportions of ſands and ſalts, by expoſing the mixture during a conſiderable time to a red heat, not intenſe enough to melt it. By this calcination, the phlogiſton of theſe matters is burnt and diſſipated, all color is deſtroyed, and the glaſs produced is alſo more clear and brilliant. This firſt mixture of materials of glaſs, when calcined, is called *the fritt*; and this fritt is uſed in large manufactories not only for the finer glaſs, but alſo for the common brown glaſs; not with an intention to render this latter kind of glaſs colorleſs, but becauſe during this calcination, the ſalts and earths begin to act upon each other, and to incorporate in a certain degree; by which a great part of the effervescence and ſwelling occaſioned by the reaction of theſe matters, which happen when they are at once expoſed to a melting heat, are avoided. Accordingly when matters not previouſly fritted are employed in ſmall experiments, the heat muſt be applied gradually; otherwiſe they ſo ſwell, that frequently the greateſt part of the mixture runs over the crucible.

The due degree of heat is an eſſential point in making of glaſs; it ought not only to be very ſtrong, but alſo maintained during a long time. In

manufactories, the glaſs is kept fuſed during ten or twelve hours before it is taken out of the pots. Accordingly their glaſs is always more perfect than that which is haſtily made in ſmall quantity in two or three hours. Good glaſs, although kept in fuſion in a very great heat, is not perfectly liquid. It is always ſomewhat thick, and when taken from the crucible, it may be drawn out into fine wire or threads; which ſhews that it has a certain conſiſtence and a very ſenſible tenacity when it is red-hot. It is not tranſparent, while it remains red-hot, not even when it has become perfectly hard. Another remarkable circumſtance is, that glaſs which is ſo brittle when it is cold and tranſparent, is very ductile when it is ſo heated as to be opake. We might be induced to believe, that the diſengaged fire with which the glaſs is filled when it is red-hot, produces upon it the ſame effect that phlogiſton, or combined fire, produces upon metals. The ductility of red-hot glaſs is very uſeful; for by its means all imaginable ſhapes may be given to glaſs, and numberleſs veſſels and utenſils may be eaſily formed of it

As ſoon as glaſs-veſſels have received their intended form, they muſt be cooled very gradually, otherwiſe they would have no ſolidity, and would be of little uſe, as they would be liable to be broken by the ſmalleſt ſtroke, or by a ſlight change of heat and cold. This inconvenience is prevented in glaſs-houſes by carrying the glaſs veſſels as ſoon as they are formed, and while yet red-hot, into an oven too little heated to deſtroy their form, but in which they may be very gradually cooled. This is called *annealing* the glaſs.

Notwithſtanding all the care taken in the manufactories of the finer kinds of glaſs, as cryſtal-glaſs and plate-glaſs, to make them perfectly good, they are nevertheleſs ſeldom found quite free from faults. The principal faults in glaſs are, colors, bubbles, and veins. The colors which generally hurt glaſs, eſpecially that kind which contains ſaline fluxes, are ſhades of green, olive, and blue. Theſe colors are deſtroyed by *manganeſe*, which being added in ſmall quantities, clears the glaſs, and is therefore ſometimes called by artiſts, *the ſoap of glaſs*. This effect of manganeſe cannot eaſily be explained, for it has the property of tinging glaſs with a purple color. Mr. Montamy, in his *Traité des Couleurs pour la Peinture en Email*, has a very fine and ingenious thought upon this ſubject, which is, that the manganeſe deſtroys the above-mentioned colors, by adding to theſe a purple tinge, and by the mixture producing a blackiſh-brown color; and that as blackneſs is cauſed merely by an abſorption of the rays of light, therefore the blackiſh tinge given to the glaſs by the above mixture of colors, prevents the reflection of ſo many rays, and thus renders the glaſs leſs colored than before. The cauſes of the bubbles and of the veins in all glaſs, even when moſt carefully prepared, and the methods of preventing theſe faults are little known. No reſearches have been made upon this ſubject, by any chemiſt excepting by Mr. D'Antic, whoſe experiments are publiſhed in the Memoirs of the Academy. But however intereſting theſe may be, this matter requires further examination. As the veins of glaſs, unleſs they be conſiderable, are ſeldom very perceptible in the finer kinds of glaſs when well compounded, and carefully made, they have therefore been hitherto neglected. Nevertheleſs we ought to inform thoſe who are intereſted in the progreſs of arts and ſciences, that ſince the important diſcovery of achromatic teleſcopes has

has been made, the correction of this fault in glaſs deſerves attention. We need only inform thoſe who would attempt this improvement of glaſs, that the object-glaſs of theſe teleſcopes is compoſed of ſeveral glaſſes of different degrees of denſity; and that the effect of this compoſition of different glaſſes is (ſuppoſing them at the ſame time to have the due curvatures), that teleſcopes may be made, which do not exhibit iriſes when looked through, which are therefore infinitely preferable to ordinary teleſcopes, and from which aſtronomy may receive much advancement.

Some great geometers have determined the denſity and the curvature that theſe object-glaſſes ought to have. But in vain have Euler, Clairaut, and D'Alembert illuſtrated this part of dioptrics by means of the moſt ſublime theory, unleſs glaſſes can be made which ſhall be capable of producing the effects required. No certain and conſtant method is yet known for making cryſtal-glaſs for this purpoſe. A celebrated Engliſh optician, Mr. Dollond, who has himſelf had a conſiderable ſhare in the diſcovery of theſe new teleſcopes, does indeed make them very good (*p*). But our opticians, who procure from England the ſame glaſs that is employed by the Engliſh opticians, affirm that this glaſs is very faulty; and that amongſt a large quantity, ſome pieces only can be found fit for the purpoſe: hence we find that it is not conſtantly made good in the Engliſh glaſs-houſes.

A certain method therefore of making ſuch a cryſtal glaſs as is required, ſtill remains to be diſcovered. Two kinds of glaſs are required for the object-glaſs of achromatic teleſcopes. One of theſe is a light cryſtal-glaſs, made with ſaline fluxes, like the French mirror-glaſs.

Good pieces of this kind of glaſs may be eaſily found. The other kind of glaſs is a denſer cryſtal-glaſs, and therefore contains ſome calx of lead in its compoſition. Such is the Engliſh flint-glaſs. The denſity of this glaſs ought to be ſuch, that a cubic inch ſhall weigh fourteen hundred grains. A perfect

(*p*) The indiſtinctneſs of the images ſeen through common teleſcopes proceeds chiefly from this cauſe, that ſome of the colored rays of light are refracted more in paſſing through glaſs, or any refracting medium, than the others, and do therefore produce priſmatic colors. The late ingenious Mr. Dollond found, that this difference of refrangibility of the colored rays was much greater when the rays paſſed through ſome kinds of glaſs, as crown-glaſs, than through others, as flint-glaſs. By adding therefore to the convex object lens of teleſcopes (which was made of crown-glaſs) a concave lens made of flint-glaſs, the curvature of which was not ſufficient to deſtroy the whole convergency of rays of light produced by the convex lens, he counteracted the error proceeding from the different refraction of the colored rays in paſſing through the convex lens, and, by thus uniting theſe ſeveral rays, formed one diſtinct image. This power of different kinds of glaſs, by which they refract differently the colored rays is not proportionable to the denſity of the glaſs; although calx of lead added to glaſs ſingularly encreaſes this difference of refraction. The author of the Dictionary ſays, that Mr. Dollond had a great ſhare in this diſcovery. He was the firſt perſon who attempted or who executed this improvement. We may indeed obſerve, that long before, in the year 1713, Dr. David Gregory, the celebrated Profeſſor of Aſtronomy at Oxford, did ſuggeſt, (in his *Catoptricæ et Dioptricæ Sphæricæ Elementa*) that by compounding the object lens of a dioptric teleſcope of ſeveral media of different refractive powers, the image might be rendered more diſtinct, in the ſame manner (ſays he) as it is done by the compounded media of the eyes of animals.

glass of this kind cannot be obtained without great difficulty. I have been assured by some intelligent persons, who have considered this subject of achromatic telescopes, that the qualities essentially requisite in this glass were, that it should be very transparent, and perfectly free from veins, to which it is very liable; and that a slight tinge of yellow and even a few bubbles were not very injurious. I have made many experiments to obtain a crystal glass free from veins, but have met with great difficulties. The veins are undulated, like those which appear when two liquors of different densities, as water and spirit of wine, are added together, and before they are well mixed. This appearance shews, that something similar happens in the making of glass. I endeavored to correct this fault by a very careful mixture, and by a compleat fusion. But I confess, that although I have exposed these glasses to very violent and long continued fires, and have several times pulverised and ground them, and repeated the fusion, I have not been able to procure any perfectly free from veins. I have been prevented by other necessary occupations from continuing my experiments on this subject. But although those which I have made sufficiently shew the difficulty of making glass of the required density, and which shall be perfectly free from veins, this difficulty nevertheless does not appear unsurmountable; and I do not doubt but that by patiently prosecuting this inquiry, we may arrive at the desired success.

We shall observe, in concluding this article, that several causes lessen or entirely prevent the transparency of glass, which is one of its most necessary qualities. As we cannot melt vitrifiable earth into transparent masses but by means of fluxes, and a sufficiently strong and long-continued heat, therefore when the vitreous mixture contains too little flux, or is exposed to too little heat, some parts of the vitrifiable earth cannot be entirely fused, and therefore impair more or less, according to their quantity, the transparency of the glass. The same fault may be perceived in glass, when it contains some earthy matter not susceptible of the action of fluxes, as vitrifiable earth is; such as, for instance, most metallic earths that are too much dephlogisticated, particularly the earth of tin. Accordingly, these earths are employed to make opake or semi-transparent glasses, as enamels, artificial opals, and other such stones. Another remark may be made concerning the transparency of some kinds of glass, that is rendered deceptible by a too long exposure to violent heat. As all fluxes, phlogistic or saline, are much less fixed than vitrifiable earth; and as some fluxes are less fixed than others, or less capable of becoming fixed by being mixed with vitrifiable earth; the cause therefore of the loss of transparency which some glasses suffer by a too violent fire, is, that a part of their flux is dissipated, so that these glasses are decomposed, and that they contain so much earth that the flux is incapable of keeping them compleatly fused. I have observed that glasses formed by a mixture of argillaceous, and gypseous or calcareous earths are more liable than any others to this loss of transparency. *See* ALKALI, EARTH, FURNACES, *and several other articles relating to vitrification.*

[illegible]. VITRIOL. This name is particularly applied to three neutral vitriolic salts with metallic bases. These salts are, 1. The combination of vitriolic acid with iron, called *martial vitriol*, *English vitriol*, *green vitriol*, or *green copperas*. 2. The salt resulting from the union of the same acid with copper, called *vitriol of copper*, *blue vitriol*, *Cyprian vitriol*, or *blue copperas*.

3. The

3. The salt composed of vitriolic acid with zinc, called *vitriol of zinc*, *white vitriol*, *white copperas*, and *Goslar vitriol*.

We have observed under the articles *vitriolic acid* and *salts*, that the name *vitriol* ought to be applied to all vitriolic salts with metallic basis. Thus, for instance, the salt composed of vitriolic acid and gold may be called *vitriol of gold*; and the salt formed by the union of this acid with silver may be called *vitriol of silver*, or *lunar vitriol*. Perhaps all vitriolic salts might be conveniently comprehended under the general name *vitriol*. The properties of vitriolic salts are mentioned at the articles, ACID (VITRIOLIC), ALKALIS, EARTH (CALCAREOUS), SALTS, SELENITES, GYPSUM, ALABASTER, SPAR, SMELTING *of* ORES, *and of the several metallic substances*.

DCCXX. UMBER. (q)

DCCXXI. VOLATILITY. Volatility is a property that many bodies have of being reduced into light vapors, which exhale when they are exposed to the action of fire. This quality is opposed to *fixity*. The cause of it is the greater or less *dilatability* which bodies have when exposed to fire. Perhaps every body is, rigorously speaking, volatile: but as there are some the volatility of which can be only rendered sensible by the action of a fire much more violent than any which we can produce, we consider these bodies as being fixed, or not volatile. *See* FIRE *and* FIXITY.

DCCXXII. URINE. As urine is an excrementitious animal liquor, it contains only such principles as are useless or hurtful to the animal economy; and is accordingly found to be nothing but a lixivium of different saline substances, which cannot enter into the composition of an animal body, together with a quantity, not very considerable, of a saponaceous, extractive, and very putrescent matter. In urine we find none of the gelatinous substance that is contained so copiously in other animal liquors that are not excrementitious; for this gelatinous substance, as we have said under the article JELLY, is the principal constituent, nutritive, and reparative part of animal bodies, and could not therefore without some considerable fault or disorder in the animal economy be rejected with any excrementitious matter. The urine of healthy animals is therefore nothing but a serous saline liquor, that may be entirely evaporated, without shewing any gelatinous matter.

The fresh urine of healthy animals is transparent, and something yellowish or citron-colored, has a slight smell, a saline nauseous taste, and does not change the color of syrup of violets to a red or to a green: but this liquor varies considerably when the animal economy, and especially the digestive organs are disturbed. Accordingly, physicians carefully observe the urine of their patients; but although they often receive much assistance from such observation, it is a dangerous error that quacks lead many ignorant persons into, to believe, that by the mere inspection of urine all diseases may be discovered.

(q) UMBER. Umber is a very light, dusky-colored earth, which is somewhat inflammable, and emits a strong smell when it is burnt. By calcination it is changed, according to Wallerius, to a white earth, and, according to Linnæus, to a red earth; whence the latter author conjectures that it contains some iron. It seems not to have been much examined.

Phyficians, who have paffed their lives in an attentive obfervation of the figns of difeafes, are too fenfible of the infufficiency of every aid to decide certainly concerning the nature of many difeafes. But this reflection ought to be a motive to inquire into the various changes that urine undergoes in different ftates of the body, more accurately than has been hitherto done, efpecially as the improvements daily made in chemiftry may give us hopes of throwing more and more light upon this and other interefting fubjects.

The qualities of urine are very apt to vary confiderably, even without any very perceptible derangement of the animal economy. For inftance, it is fometimes much more copious than at other times. This difference of the quantity of urine has been obferved to depend much on the quantity of perfpiration and of fweat that have been exfuded at the fame time; for the nature of thefe fluids is very fimilar to that of urine. Generally, when the urine is in fmall quantity, it is deeper colored; and reciprocally.

The urine of perfons afflicted with hyfterical and melancholical fpafms is frequently copious, limpid, and purely watery or ferous, without color or fmell. This urine is called *crude urine.* Thefe fame perfons do alfo frequently difcharge urine in fmall quantity, that is high-colored, that has a ftrong fmell, and that quickly becomes turbid when expofed to cold. We may obferve, that the fediment which renders this urine turbid may be again rediffolved by more frefh and warm urine, and is therefore of a faline nature.

Certain odoriferous fubftances, taken internally, as turpentine, afparagus, and others, are well known to communicate quickly their fmell to urine, even in perfect health: but I have alfo feen perfons fubject to pains of the head and to bad digeftion, proceeding from a melancholic or hyfterical temperament, who difcharged urine, in which I could evidently perceive the fmell of coffee, fpices, onions, fruits, roots, and even of broth, and other aliments. The urine of thefe perfons was habitually acid, reddened fyrup of violets and blue paper, when it was recent, and efpecially after eating fruits and roots, or drinking even a very fmall quantity of wine.

From thefe two latter obfervations we may perceive, that urine depends much on the ftate of digeftion, the faults of which may therefore be difcovered by examining that liquor.

Urine is ftrongly difpofed to putrefaction. In ten or twelve hours, when the weather is warm, it acquires a ftrong fmell; and in great heats, this fmell may be perceived in five or fix hours. The beginning of the putrefaction of this liquor may be perceived by a putrid, difagreeable, but not pungent fmell. The fmell afterwards becomes pungent, and difcovers a volatile alkali, which is very copioufly difengaged in the putrefaction of this liquor. Although the difagreeable fmell that is perceived at firft in urine beginning to putrefy has not the pungency of volatile alkali, it neverthelefs feems to be produced by this falt; for by mixing any acid with urine in this ftate, its fetid fmell is immediately deftroyed. By the fame means alfo the fmell of veffels in which urine has been contained may be deftroyed. On the contrary, by mixing fome fixed alkali or quicklime with frefh urine, a pungent fmell of volatile alkali and of putrid urine is inftantly produced. As in fo fhort a time no real putrefaction can happen, we muft attribute the difcharge of volatile alkali in this experiment to

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a decompoſition of a ſal ammoniac, which is contained in the freſheſt urine, as we ſhall ſoon ſhew.

If the freſh urine of a healthy perſon be diſtilled in cloſe veſſels, nothing is obtained from it with the heat of boiling water, but a pure phlegm with a ſlightly nauſeous ſmell. This phlegm is generally $\frac{7}{8}$ parts or more of the whole urine; but the quantity of this and of the other principles of urine are very various.

As nothing but phlegm is ſeparated at firſt in this diſtillation, when therefore urine is to be analyſed, the operation may be accelerated and ſimplified by evaporating it over the fire in an open veſſel. We may then obſerve, that while the phlegm of the urine is evaporated, the remaining liquor becomes turbid, and depoſites a certain quantity of matter which is almoſt entirely earthy. The quantity of this earth varies alſo according to the nature of the urine. It deſerves a particular examination. The obſervations of Mr. Heriſſant, Phyſician of the Faculty of Paris, and Member of the Academy of Sciences, concerning the urine of ſeveral perſons afflicted with diſeaſes in which the bones were affected and waſted *(See Memoirs of the Academy for the year* 1758); and thoſe alſo of Mr. Morand, of the ſame Faculty, and Member of the ſame Academy, concerning the urine of a woman whoſe bones were entirely ſoftened by the loſs of their earthy matter, which was found to contain a conſiderable quantity of earthy ſediment; ſhew, that the earthy ſediment of urine, which is firſt depoſited by evaporation, is partly at leaſt of the ſame kind as the earth of bones; and that in a healthy ſtate, nature throws off by the urinary paſſages all the earthy matter that is not required for the encreaſe or reparation of the bones. This earthy ſediment appears alſo in putrid urine.

While the urine evaporates, the remaining part of it acquires a more and more deep brown color, by the approximation of the ſaponaceous extractive parts which it contains. When, by evaporation, it has acquired the conſiſtence of a clear ſyrup, or of freſh cream of milk, it ought to be put in a cool place, that the ſeveral neutral ſalts which it contains may be cryſtallized. The firſt cryſtals that are obtained are a particular kind of ſalt known to chemiſts by the names, *native* or *eſſential ſalt of urine*, *fuſible ſalt of urine*, *phoſphoric ſalt*, and *microcoſmic ſalt*. This ſalt contains the acid proper for making phoſphorus. Some part of this ſalt has a baſis of volatile alkali, and is therefore a kind of ammoniacal ſalt; and the reſt has a baſis of fixed alkali. *See* SALT (FUSIBLE) *of* URINE, *and* PHOSPHORUS *of* KUNCKEL. When the urine contains any ſalts that are more cryſtallizable or leſs ſoluble than the fuſible ſalt, as it frequently does, ſuch as ſelenites, vitriolated tartar, and others, theſe are firſt cryſtallized, eſpecially if they be in conſiderable quantity. *See* CRYSTALLIZATION.

By alternately evaporating and cooling the liquor, the other leſs cryſtallizable ſalts, ſuch as common ſalt, a great quantity of which urine generally contains, may be ſeparated. In the urine of different animals all the neutral ſalts are generally found which they have taken, either along with their aliments or otherwiſe; becauſe theſe ſalts, not being uſeful in the compoſition of animal matters, after having circulated ſome time in the blood-veſſels, are carried off, unchanged, along with the urine.

After all the neutral ſalts have been obtained from urine, nothing remains but a brown, ſaponaceous, extractive matter, which forms a kind of mother-

water. This matter yields, with a naked and graduated fire, a conſiderable quantity of volatile alkali, both fluid and concrete, together with ſome fetid animal oil. With the utmoſt violence of fire, a ſmall quantity of phoſphorus may alſo be obtained; and a little common ſalt may be ſeparated from the reſiduous coal. This phoſphorus is produced by a little fuſible ſalt which was not ſeparated by cryſtallization, but remained, together with the above-mentioned ſmall quantity of common ſalt, diſſolved in the liquor.

From this analyſis of urine we may perceive, that it is compoſed of a large portion of pure water, in which is diſſolved a conſiderable quantity of earthy matter, that forms the ſediment of urine; of two phoſphoric ſalts, one of which is ammoniacal, and the other has a baſis of fixed alkali; of common ſalt; and, laſtly, of a ſaline, ſaponaceous matter, which contains a combined oil. In urine no gelatinous matter nor uncombined oil are found.

Such is the ſtate of our preſent knowledge concerning the nature and principles of urine. It certainly is capable of receiving much addition from future inquiries, by which medicine might be much improved; but we muſt, at the ſame time, confeſs, that we cannot receive all the knowledge we wiſh upon this ſubject without very long and laborious operations. The moſt important point to be known is the compoſition and proportions of the ſeveral conſtituent parts of urine: but, as we have already remarked, theſe are very variable, according to the ſtate of health or of ſickneſs, to the differences of conſtitutions, aliments, exerciſes, diſeaſes, medicines, and perhaps even to the variations of the atmoſphere. A knowledge of the differences of the urine in all theſe ſeveral circumſtances is very important, but can only be acquired by a long and zealous obſervation of thoſe phyſicians who are inſtructed in the ſeveral ſciences relative to their profeſſion.

DCCXXIII.

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DCCXXIII. WAND (DIVINING). The divining wand is an inftrument, by means of which many perfons have formerly pretended, and fome do now pretend, to difcover under what parts of the earth metals, treafures, ores, water, falt, &c. lie hid, without digging the ground. They fay, this difcovery may be made by a perfon holding the wand horizontally, and by walking along in places where thefe matters are expected; and that when he arrives at a place under which any of the abovementioned matters lie, the wand will be forcibly inclined towards that place: but that this experiment fhould fucceed, much faith feems to be required in the perfon who holds the wand, or rather in the fpectators. We may eafily perceive, that the power of this wand is a chimera, which owes its reputation to avarice, to ignorance, and to credulity.

The famous Father Kircher, in his *Mundus Subterraneus*, in which many interefting particulars are found concerning mines, juftly derides thefe fuperftitious practices, and denies, from his own experience, the truth of the affertions concerning them. He feems, however, to have fome faith in fympathies, and propofes even new divining wands of his own invention; the effects of which, though more dependant on phyfical caufes, are not however more certain. He believes, for inftance, that a wand, one end of which fhould be made of fal gem, and the other of wood, being fufpended and balanced above a mine of falt, would be inclined towards the ground; and he fupports his opinion by an experiment. This experiment confifts in evaporating over the fire a folution of fal gem, below the wand, which is by this means really made to incline. We need not be deeply learned in chemiftry to difcover, that the wand would have inclined in the fame manner if Father Kircher had evaporated pure water inftead of a folution of fal gem; becaufe the water would have equally well attached itfelf to the faline end of the wand; confequently this experiment proves nothing.

The fame author propofes alfo to difcover mines of mercury by employing a wand, one end of which is made of gold, and the other of wood, in hopes that

that the emanations of the mercury would attach themſelves to the gold rather than to the wood, and would make it incline downwards. But this effect certainly cannot be produced unleſs the mercury was evaporating; for which purpoſe two conditions are neceſſary: 1. The mercury muſt be in a native metallic ſtate, and not mineraliſed, as it is in cinnabar; and, 2. It muſt alſo be expoſed to the heat of ſome ſubterranean fire, by which it is volatiliſed and ſublimed, the ordinary heat of the earth being far too little for this purpoſe. This ſecond phyſical or chemical divining wand propoſed by Father Kircher is therefore no better than the former; and probably the ſame judgment may be paſt upon all other wands made upon the ſame principles, and in imitation of theſe. Laſtly, the ſame author poſitively affirms, that he hung and balanced a wand, one half of which was made of alder-tree, and the other half of ſome wood that has no ſympathy with water, over a ſubterranean water, and that he obſerved the end of the wand incline towards the earth.

DCCXXIV. WATER. Water, perfectly pure, (for of ſuch only we treat in this article) is a tranſparent body, without color, without ſmell, and without taſte.

Water is very volatile, and ſo very fuſible, that it is conſtantly liquid with a leſs degree of heat than is requiſite for vegetation: hence it is generally conſidered as a liquid. But when it is expoſed to a leſs degree of heat, it becomes ſolid, like all other bodies naturally ſolid, which reſume their ſolidity when they are no longer expoſed to a heat ſufficient to keep them in fuſion.

When water, that is expoſed to a degree of cold ſufficient to render it ſolid, paſſes from a fluid to a ſolid ſtate, this change is called the *congelation* or *freezing of water*; and the water thus rendered ſolid is called *ice*.

When water is frozen with all the circumſtances neceſſary for the free arrangement of the integrant particles of bodies (which circumſtances are explained under the article CRYSTALLIZATION), it aſſumes determinate and regular forms. M. de Mairan, in his excellent Treatiſe on Ice, has determined, that theſe regularly formed maſſes of frozen water are like needles croſſing each other, or rather infixed into each other, ſo as always to form two angles, one of which is equal to ſixty degrees, and the other equal to a hundred and twenty degrees.

This regularity in the congelation or cryſtallization of water ſhews, that it is a body not much compounded. We ſhall ſoon ſee that it is one of the ſimpleſt of all known bodies.

Water is not compreſſible. This truth is aſcertained by a famous experiment, which conſiſts in including water in a hollow ſphere of metal hermetically cloſed, and in expoſing this ſphere to a very ſtrong compreſſion, by which means the water is forced through the pores of this metallic ſphere rather than ſuffer any compreſſion. *(r)*

(r) The validity of the inferences drawn from this experiment, called the *Florentine experiment*, has been juſtly queſtioned. An ingenious philoſopher, Mr. Canton, has proved, by experiments ſhewn to the Royal Society, that water is actually compreſſed by the weight of the atmoſphere. The diminution of ſize that water ſuffers when it paſſes from a greater to a leſs degree of heat, till it begins to freeze, ſufficiently ſhews, that the integrant parts of this fluid are, like thoſe of all other known ſubſtances, capable of approximation.

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The ſpecific gravity of water, compared with that of air in a temperature intermediate betwixt the greateſt ſummer heats and the greateſt cold of winter, has been determined by the beſt experimental philoſophers to be nearly as 850 to 1; that is to ſay, that any given bulk of water is 850 times heavier than an equal bulk of air.

We have ſaid above, that water is a very volatile body. It is entirely reduced into vapors and diſſipated, when it is expoſed to the fire, and is not confined.

When water is heated in an open veſſel, and is unconfined, it has been obſerved to acquire no more than a certain determinate degree of heat, whatever be the intenſity of the fire to which it is expoſed; which greateſt degree of heat is that which it has when it boils quickly. This degree of heat, and alſo that degree at which water begins to freeze, are fixed and determinate, and are therefore very uſeful in many chemical and phyſical experiments. By means of theſe fixed points of heat, we have been enabled to conſtruct thermometers, which may always be compared one with another; and we have alſo been enabled to apply preciſe and determinate degrees of heat, which are neceſſary in many chemical operations. *See* BATH (WATER).

Some philoſophers have ſaid, that the property which water and ſome other bodies have, of acquiring only a determinate degree of heat, proceeds from the rarefaction cauſed by this degree of heat, by which means the fire penetrates them freely and without any reſiſtance. *See* FIRE. But this opinion is erroneous. The cauſe of this phenomenon evidently is, that water being volatile, is reduced into vapors which are conſtantly exhaled and removed from the fire, the action of which they elude as ſoon as they ſuffer a certain degree of heat, as may be proved by the following conſiderations.

Firſt, none but volatile bodies have this property; bodies abſolutely fixed being capable of acquiring indefinite degrees of heat: hence the more volatile a body is, the leſs heat it can acquire, and reciprocally; or, to ſpeak geometrically, the degrees of heat which bodies expoſed to the action of fire, and unconfined, can acquire, are inverſely as their volatility, and conſequently directly as their fixity.

Secondly, when water and all volatile bodies are expoſed to the action of fire, and ſo confined that they cannot freely evaporate or elude that action, they are then capable of acquiring a degree of heat that is much more conſiderable, is indeterminate, or rather proportionable to the force with which they are confined, and prevented from evaporating.

We have an obvious example of this in the effects of *Papin's Digeſter*. Water being confined in this veſſel ſo that it cannot evaporate, is capable of acquiring a degree of heat much greater than that with which it boils in open air, and even ſufficient to make it red hot.

Upon this ſubject we muſt obſerve, that when water, or other volatile bodies, are thus expoſed to a greater degree of heat than is ſuited to their volatility, they are in a violent ſtate; and are therefore apt to break any veſſels that confine them, with an exploſion ſo much more violent, as they are more ſtrongly compreſſed, and are expoſed to a more violent and more ſuddenly applied heat.

Hence we may conceive why water expoſed to heat too ſuddenly to allow it to evaporate gradually occaſions terrible exploſions; as, for inſtance, when

water

water is thrown upon very hot oil, or when a melted and red-hot metal is poured into a moiſt veſſel.

We ought to obſerve upon the ſubject of theſe exploſions, that they only happen when the volatile bodies are in an aggregate ſtate, or are combined with other volatile bodies; for the moſt volatile ſubſtances, when combined with fixed bodies, may be expoſed to the moſt violent heat without producing theſe effects Thus water, when combined with quicklime, with fixed alkali, and other ſalts, may be ſuddenly expoſed to a red-heat without danger of exploſion.

Water ſeems to be unalterable and indeſtructible: at leaſt, no experiment is hitherto known from which we may infer that water may be decompoſed. With whatever ſubſtances it may be combined, when ſeparated from theſe and ſufficiently purified, it is always found to be the ſame as before. When it is diſtilled ſingly, or mixed with ſome other ſubſtance, its nature and eſſential properties ſtill remain unchanged.

Some philoſophers, as Boyle, and eſpecially Mr. Margraaf, having very frequently diſtilled the ſame water, obtained at each operation a ſmall portion of earth; but the water which was diſtilled remained always eſſentially the ſame. The ſmall quantity of earth ſeparated from the water ought to be conſidered as extraneous to it.

The famous experiment of Van Helmont, which has ſince his time been more carefully repeated by others, and which conſiſts in making trees and plants grow merely by means of water, does not prove, as ſome have ſuppoſed, that pure water is convertible into earth, ſalts, oil, and the other principles of vegetables; becauſe water not only contains a ſmall quantity of earth mixed with it, but alſo the air alone is the vehicle of a conſiderable quantity of theſe principles, or of ſuch as are capable of producing them.

Water therefore appears to be a body ſimple and unalterable: at leaſt, chemiſts, not having any means of decompoſing it, may conſider it as ſuch. They have accordingly claſſed it amongſt the *elements* or primary principles. *See* ELEMENTS *and* PRINCIPLE.

Many experiments and chemical analyſes ſhew, that water enters as a principle in the combination of many compound bodies, ſuch as all ſaline and oily ſubſtances (*See* SALT *and* OIL); and conſequently that it is a part of all vegetable and animal matters, and of all the ſaline parts of minerals. Several ſtones even, in which no ſaline matter appears, as calcareous ſtones, contain a certain quantity of water, which ſeems to be in a ſtate of combination. *See* EARTH (CALCAREOUS) *and* QUICKLIME. But hitherto no experiment ſhews, that water enters as a principle into the combination of *metallic matters*, or even into that of *vitreſcible ſtones*. *See theſe words.*

Water diſſolves many bodies. It ſeems to be capable of diſſolving a certain quantity of air; for all natural water being placed under an exhauſted receiver emits many air-bubbles; and, according to Mr. Muſſchenbroek, the water from which air has been thus ſeparated, is capable of reſuming the ſame quantity of air; that is to ſay, if a ſmall quantity of air be introduced into this water, it will not form a bubble, as it would with water already ſaturated with air, but incorporates with the water, and entirely diſappears.

Water ſeems alſo capable of diſſolving a ſmall quantity of calcareous earth; for the moſt limpid, clear water being diſtilled, always depoſites ſome part of

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this earth. Some very limpid ſpring waters contain ſo much calcareous earth, that they depoſite a ſediment which encruſts any bodies that happen to be immerſed in them. Theſe waters become thus impregnated by flowing through large quantities of calcareous earth. Such are the waters of D'Arcueil near Paris, and all thoſe which form incruſtations, petrefactions, and ſtalactites. This earth does not ſeem to adhere very ſtrongly to the parts of water, eſpecially when it is in conſiderable quantity. It ſeems to be in an intermediate ſtate betwixt that of ſimple mixture and of perfect combination with the water.

Metallic matters, excepting the perfect metals, are acted upon by water, but eſpecially by the vapor of water, together with the concurrence of air. It converts their ſurfaces into ruſt, and deprives them of part of their inflammable principle. It does not appear to be diſpoſed to unite with the principle of inflammability; for all the bodies that are abundantly furniſhed with this principle reſiſt the action of water, unleſs they have alſo ſome other principle that may ſerve as an intermediate ſubſtance for this union.

But, of all known bodies, ſaline ſubſtances are moſt eaſily and copiouſly ſoluble in water. A ſtrong affinity is obſervable between this element and all ſaline ſubſtances; ſo that we may ſay in general, that all ſalts are ſoluble in water; that every body truly ſoluble in water is of a ſaline nature; and that no other body can be diſſolved in water but by means of a ſaline ſubſtance. *See* SALTS.

Spirit of wine, and all ardent ſpirits of the ſame kind, may be diſſolved in water in all proportions. *See* SPIRIT (ARDENT).

The ſpiritus rector of vegetable and animal ſubſtances, and moſt of the very thin and very volatile fluids, called *gas*, are ſoluble in water. *See theſe words.*

Ethereal liquors, as vitriolic, nitrous, marine, and acetous ethers, are ſoluble in water, but only in certain proportions. *See* ETHER.

Water diſſolves the moſt ſubtle and volatile part of any oils, as Mr. Beaumé has obſerved. *See* OILS.

Compounds, formed of any oily matters united with ſaline matters, (to which compounds we ought to give the general name of *ſoap*, or *ſaponaceous ſubſtance*) are ſoluble in water, ſo much more eaſily and copiouſly as their ſaline principle is in greater quantity, and more diſengaged or unfolded. *See* SOAP.

Laſtly, water is the proper ſolvent of all mucilaginous, gummy, and gelatinous matters; which matters are compoſed of ſaline, oily, and earthy principles. *See* GUM.

We may eaſily perceive from what has been ſaid concerning the properties of water, that it muſt be very uſeful in many chemical operations: but as it diſſolves ſo many bodies, it can ſeldom be found naturally free from heterogeneous matter, or perfectly pure. The waters of rivers and of ſprings, however limpid they may be, always contain a certain quantity of earth, which is in the intermediate ſtate above-mentioned, between a ſimple interpoſition of parts, and a true ſolution. The beſt waters of this kind are thoſe which flow through ſands, gritt-ſtone, and other vitrifiable matters; becauſe vitrifiable earth is leaſt capable of being attacked by water.

The waters of many ſprings and rivers contain more or leſs of a gypſeous or ſelenitic ſubſtance really diſſolved; for as water is capable of diſſolving theſe matters, and often flows through grounds containing them, it muſt diſſolve a certain quantity of them, and even as much as ſaturates it. Waters impregnated with ſelenites are unfit for chemical operations, for being drank, for diſſolving ſoap, or for boiling leguminous vegetables. They are a kind of *mineral waters*, and are called *crude* or *hard waters*. *See theſe words.*

Rain or ſnow-waters, properly collected, that is, not in ſtormy weather, after it has already rained or ſnowed ſome time, in open air, and far from the habitations of men, and received in earthen-ware veſſels, are the beſt and the pureſt of all native waters. They are ſufficiently pure for moſt chemical operations, becauſe they have been purified by a kind of natural diſtillation: but for greater exactneſs, and becauſe theſe waters are not always procurable, diſtilled water is generally employed in chemical operations. *See* WATER (DISTILLED).

(*s*) Native water is ſeldom, if ever, found perfectly pure. The *waters* that *flow within*, or *upon the ſurface of*, *the earth* contain various earthy, ſaline, metallic, vegetable or animal particles, according to the ſubſtances over or through which they paſs. *Rain* and *ſnow-waters* are much purer than thoſe, although they alſo contain whatever floats in the air, or has been exhaled along with the watery vapors. Mr. Margraaf has very accurately analyſed ſome rain and ſnow-waters, and found that they contained a calcareous earth united with nitrous and marine acids, the rain poſſeſſing more of the former, and the ſnow more of the latter acid, together with ſome mucilaginous, oily, and ferruginous particles. The quantity of calcareous earth ſeparated, by adding a fixed alkali, from a hundred meaſures of water, each of which contained 36 ounces, was 132 grains; and the quantity ſeparated by the ſame means from an equal quantity of ſnow-water was 72 grains.

The *purity of water* may be known by the following marks or properties of pure water.

1. Pure water is lighter than water that is not pure; for not only the ſubſtances uſually diſſolved in water, fixable and atmoſpherical air excepted, are heavier than water, but alſo the ſpecific gravity of a ſolution of any of theſe ſubſtances in water is greater than the intermediate ſpecific gravity of the water and of that ſubſtance. We muſt nevertheleſs obſerve, that as fixable and atmoſpherical airs are frequently contained in water, they render it leſs heavy than it would otherwiſe be. Hence Bath, and other waters containing much fixable air, are lighter than diſtilled water, although the former contain ſaline, metallic, and earthy ſubſtances.

2. Pure water is more fluid than water that is not pure: hence it is ſaid to occaſion a louder ſound when poured from one veſſel into another.

3. It has no color, ſmell, or taſte.

4. It wets more eaſily than the waters containing metallic and earthy ſalts, called *hard waters*, and feels ſofter when touched.

5. Soap, or a ſolution of ſoap in ſpirit of wine, mixes eaſily and perfectly with it.

6. It is not rendered turbid by adding to it a ſolution of gold in aqua regia, or a ſolution of ſilver, or of lead, or of mercury in nitrous acid, or a ſolution of ſugar of lead in water.

Boerhaave, the author of this Dictionary, and other chemiſts, maintain, that pure water is unalterable; and others, as Borichius, Boyle, Wallerius, that it may be decompoſed or reſolved into other principles, eſpecially into earth.

Boyle relates, that one ounce of water, diſtilled carefully in glaſs-veſſels two hundred times, yielded ſix drams of a white, light, inſipid earth, fixed in the fire, and indiſſoluble in water. Boerhaave attributed the earth obtained by diſtillation of water to duſt floating in laboratories. Other chemiſts have made experiments to aſcertain the truth of that of Mr. Boyle. Liedenfroſt found, that when pure diſtilled water is diſſipated or evaporated by throwing it into a red-hot iron ſpoon, he always obtained a quantity of earth. Wallerius obtained a ſcruple and a half of fine white earth by triturating during two hours a dram of diſtilled water.

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DCCXXV. WATERS (AROMATIC). Those are called aromatic waters that are impregnated by distillation with the spiritus rector, or odoriferous principle of aromatic matters. *See* WATERS (DISTILLED).

This earth, he says, is soluble in acids, is convertible into a hard mass by a red-heat, which mass is unsoluble by acids, and is vitrifiable into a white transparent glass by a more violent heat. He found also, that a large quantity of earth is deposited from boiling water with a strong, then with a gentle fire. *See the Swedish Memoirs for the year* 1760. Mr. Margraaf has made experiments with his accustomed accuracy, from which it appears, that, by distillation, and also by evaporation with the heat of the sun, of rain water, the purity of which had been previously ascertained by thirteen distillations, he obtained a white, light, shining earth. This earth could not be vitrified with the heat requisite for the fusion of ordinary glass; but by a more violent and longer continued fire it was melted into a yellow-greyish mass. He found, that about half of this earth was soluble in nitrous acid, and that the other half was not fusible by fire; but that, by addition of half its quantity of salt of tartar, it was convertible into a transparent glass. The part of the earth that was dissolved in nitrous acid was afterwards precipitated from that acid by vitriolic acid, with which it formed a selenites; and hence Mr. Margraaf infers, that it is a true calcareous earth. He does not determine the class of earths to which the unsoluble part of the earth thus obtained by distilling water ought to be referred. Mr. Margraaf observes, that earth is more copiously deposited from water boiling with a strong than with a gentle heat. The quantity of earth that he obtained, in one experiment, from 72 ounces of distilled water, by twelve distillations, was nine or ten grains.

Mr. Eller relates an account of a more extraordinary alteration produced upon water, by which other principles were formed. He enclosed some distilled water in a glass phial, which he then hermetically sealed, and exposed during some weeks in summer to the rays of the sun. At the end of this time he perceived that it was become turbid, and covered with a scum or pellicle. By distillation he obtained from this water a reddish oil, and some acid fumes. That so extraordinary an alteration can be produced upon pure water by the rays of the sun, cannot be admitted till the experiment has been carefully repeated with the same success.

To this article we shall subjoin three tables of different authors, shewing what quantity of each salt is soluble in a given quantity of water; and also an account of some experiments made by Mr. Eller, to shew how much of certain salts may be dissolved in given quantities of water saturated previously with other salts.

The following table shews the quantities of the saline substances that could be dissolved in an ounce of water, with the heat of 50° of Fahrenheit's scale, according to experiments made by Mr. Spielman. *Instit. Chemiæ, p.* 48.

	Grains
Terra foliata tartari	470
Salt of Sedlitz	384
Epsom salt	324
Salt of tartar	240
Vegetable salt	212
White vitriol	210
Sal gem	200
Salt of soda	200
Sal ammoniac	176
Common salt	170
Salt of Glauber	168
Salt of Lorraine	168
Salt of Sylvius	160
Salt of Seignette	137
Blue vitriol	124
Green vitriol	80
Purified nitre	60
Salt polychrest of Glaser	40
Vitriolated tartar	30
Sublimate mercury	30
Borax	20
Alum	14
Volatile salt of amber	5
Arsenic	5
Crude tartar	4
Cream of tartar	3

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DCCXXVI. WATER (DISTILLED). Moſt natural waters contain ſome heterogeneous ſubſtances that render them impure; and as water exceedingly pure is required for many chemical operations, it muſt be therefore purified for theſe purpoſes by diſtillation. Water may be diſtilled in the following manner:

The following table is copied from Mr. Muſchenbroek. The eight firſt experiments were made by Boerhaave, and the reſt by Muſchenbroek, with a heat of 38°.

Sea-ſalt,	oz. 2.	were diſſolved in	oz. 6. and dr. 3.	of pure water.
Sal gem,	oz. 1.	—	oz. 3. and dr. 2.	—
Sal ammoniac,	oz. 1.	—	oz. 3. and dr. 2.	—
Nitre,	dr. 9.	—	oz. 6.	—
Borax,	dr. 4.	—	oz. 10.	—
Alum,	oz. 1.	—	oz. 14.	—
Epſom ſalt,	oz. 1.	—	oz. 1. and dr. 2.	—
Green vitriol,	dr. 1½	—	oz. 3.	—
Arſenic,	oz. 1.	—	oz. 30.	—
Blue vitriol,	gr. 50.	—	gr. 850.	—
Salt of hartſhorn,	gr. 50.	—	gr. 765.	—
Sugar of lead,	gr. 50.	—	gr. 595.	—
Salt of tartar,	gr. 50.	—	gr. 85.	—
Glaſs-gall,	gr. 50.	—	oz. 7½.	—
Cream of tartar,	gr. 50.	—	gr. 1000.	of boiling water.

[Fifty grains of cream of tartar may be diſſolved in 100 grains of lime-water. *Hiſt. de l'Acad. Royale.* 1732.]

Sugar of milk, dr. 7. were diſſolved in lb. 1. of water heated to the 167°.

According to Neuman's experiments, the quantity of ſalt ſoluble in an ounce of water are expreſſed in the following table. He does not mention the heat employed.

White powdered ſugar,	oz. 2.
Brown powdered ſugar,	oz. 2.
White or brown ſugar candy,	dr. 9.
Sal diureticus	oz. 1.
Epſom ſalt,	oz. 1.
Sedlitz ſalt,	dr. 6.
Pure fixed alkali,	dr. 6.
White vitriol,	oz. ½.
Martial vitriol,	oz. ½.
Sal gem,	dr. 3. ſcr. 1.
Sea-ſalt,	dr. 3.
Salt of Glauber,	dr. 2.
Sal ammoniac,	dr. 2.
Vol. ſal ammoniac,	dr. 2.
Potaſh,	dr. 2.
Blue vitriol,	dr. 2.
Pure nitre,	dr. 1. gr. 10.
Sal prunell,	dr. 1.
Soluble tartar,	dr. 1.
Alum,	ſcr. 2½.
Sal polychreſt,	ſcr. 2.
Arcanum duplicatum,	dr. ½.
Vitriolated tartar,	dr. ¼.
Sugar of milk,	ſcr. 1.
Sugar of lead	ſcr. 1.
Emetic tartar,	ſcr. 1.
Borax,	gr. 15.
Salt of ſorrel	gr. 10.
White tartar,	gr. 5.
Cryſtals of tartar,	gr. 5.

Water, when ſaturated with one ſalt, is capable of diſſolving a conſiderable portion of another ſalt; and when ſaturated with this alſo, it may ſtill diſſolve a third, a fourth, or more ſalts. Thus, according to Neuman, four ounces of water that have been ſaturated with a dram and a few grains of alum, will ſtill diſſolve five drams of nitre, then half an ounce of green vitriol, ſix drams of common ſalt, three drams of ſoluble tartar, and five drams of ſugar. In the ſame manner alſo, four ounces of water ſaturated with half an ounce of nitre, will diſſolve half an ounce of white vitriol, ſix drams of common ſalt, ſix drams of ſal ammoniac, half an ounce of ſoluble tartar, and

The pureſt natural water that can be procured, as the water of rain or of ſnow, or of ſprings and rivers that flow over ſands, and are very limpid, is to be put into a well-tinned copper alembic, which muſt be very clean, or which is only employed for this purpoſe, and the diſtillation is to be promoted with a gentle fire.

The firſt portion of water that paſſes into the receiver ought to be thrown away, becauſe it waſhes the alembic and receiver, and becauſe if the water contained accidentally any volatile heterogeneous matters, theſe will riſe with the firſt portion of diſtilled water.

The diſtillation is to be diſcontinued, when two-thirds of water have nearly paſſed, becauſe what remains in the alembic, is loaded with a larger proportion of heterogeneous ſubſtances, ſome of which the water might raiſe along with it in diſtillation. *See* DISTILLATION.

Diſtilled water ought to be put into very clean bottles, and ſtopped with glaſs ſtopples.

Water is known to have been ſufficiently purified by diſtillation, when it does not change the color of the tinctures of violets, or of turnſol, and when its limpidity is not hurt by adding to it ſolutions of mercury or of ſilver in nitrous acid.

DCCXXVII. WATERS (DISTILLED). The *diſtilled waters of plants*, or of *other matters*, are prepared by diſtilling water from theſe ſubſtances, and are thus impregnated with ſuch principles as may be raiſed by diſtillation, with the heat of boiling water.

If the plants thus expoſed to diſtillation with water, manifeſtly contain volatile principles, as all thoſe do which have a diſtinguiſhing ſmell, we cannot doubt

and after all theſe, an entire ounce of ſugar.

Mr. Eller has publiſhed an account of the following experiments concerning the ſolution of different ſalts in the ſame water. *See Mem. of the Acad. of Berlin for the year* 1750.

In each experiment he employed *eight ounces of diſtilled water*. He found that this quantity of water, when ſaturated

With four ounces of nitre, diſſolved one ounce, five drams of fixed alkali, and half an ounce of common ſalt:

With three ounces, one dram, and one ſcruple of common ſalt, diſſolved three drams of nitre, and five drams of fixed alkali:

With three ounces and a half of foſſil ſalt, diſſolved half an ounce of nitre:

With half an ounce of cream of tartar, diſſolved half an ounce of Sedlitz ſalt, and half an ounce of fixed alkali:

With an ounce and a half of vitriolated tartar, diſſolved half an ounce of fixed alkali:

With three ounces and a half of Glauber's ſalt, diſſolved two drams of nitre, and as much ſugar.

With four ounces of ſoluble tartar, diſſolved half an ounce of pure nitre.

With four ounces of Epſom ſalt, diſſolved half an ounce of fine ſugar.

With two ounces and a half of ſal ammoniac, diſſolved five drams of foſſil ſalt.

With an ounce and a half of volatile ſalt of hartſhorn, diſſolved an ounce of nitre and half an ounce of ſugar.

With four drams and two ſcruples of borax, diſſolved half an ounce of fixed alkali.

With two ounces and a half of alum, diſſolved ſix drams of common ſalt, and one dram of Epſom ſalt:

With nine ounces and a half of green vitriol, diſſolved an ounce and a half of Sedlitz ſalt, two drams of nitre, and three ounces of refined ſugar:

With nine ounces of blue vitriol, diſſolved an ounce of nitre, three drams of common ſalt, and an ounce of ſugar:

With four ounces and a half of white vitriol, diſſolved one ounce of refined ſugar.

that

that their distilled water must be impregnated with their odoriferous principle, or spiritus rector. These waters are called *aromatic waters*. *See* SPIRITUS RECTOR.

The water that is used in the distillation of all essential oils is found much impregnated with the odoriferous principle of the aromatic plants employed; and consequently it is a good distilled water of these plants.

An opinion seems to have formerly prevailed, that even the plants called *inodorous*, might impregnate water with some of their principles by distillation; for such distilled waters are prescribed in many dispensatories. But lately, these distilled waters have been neglected, and are even considered only as common water. This latter kind of distilled waters is sensibly less impregnated with principles than the former. But are we certain that they contain nothing of the principles of the plant? Are those plants whose smell is not very perceptible, entirely destitute of all odoriferous principle? Could not a person whose sense of smell was very acute and much exercised, distinguish plantain and other herbs commonly called inodorous from each other by smell, especially if they were previously cut and bruised?

We may also observe, that the manner commonly employed for distilling such waters is not well adapted to procure all the peculiar smell and qualities of the plants employed. The plants are generally put into an alembic, and overwhelmed with a large quantity of common water. The distillation is then promoted; the water is made to boil quickly; and the vessels are seldom even luted. What can be expected from this bad management, but that the spiritus rector of these plants that is in very small quantity, and perhaps exceedingly volatile and fugacious, should be entirely dissipated; or if any of it remains in the water, that it should be disguised and covered by the empyreumatic smell that all these waters have when newly distilled, or by the smell which they acquire by time, so that they cannot be distinguished from each other?

But if we follow exactly the excellent method directed in the Paris Dispensatory; or if we improve upon this by putting the herbs recent, cut, and bruised, into an alembic placed in a water-bath, without adding water to them, and by distilling to dryness, with a very gentle heat and well luted vessels; and if we then find that the small quantity of water thus distilled from plants called inodorous has no smell nor taste, and gives all the chemical proofs of pure water, we may then justly consider these waters as destitute of any of the principles and virtues of the plants employed.

Waters called simply *distilled waters*, are understood to be those that are prepared with common water. But as spirit of wine is also frequently impregnated with the odoriferous principle of plants and other substances by distillation, and as these also have been called *waters*, they ought to be distinguished by the name, *aromatic spirituous waters*. Such are the *spirituous water of Lavender*, the *spirituous water of thyme*, &c. These spirituous waters are also sometimes called *spirits*, as *spirit of thyme*, *spirit of citrons*, &c.

Aromatic spirituous waters are impregnated with the smell of one substance only, or of several substances. The former are called *simple*, and the latter, *compound*.

Many of these waters are prepared for the uses of medicine, of the toilette, and of the table. The preparation of these waters requires only the usual attentions to be given to all distillations. Whatever relates to this subject may be found in *Mr. Beaumé's Elements of Pharmacy*. We shall there see that the strength

ſtrength and agreeable flavor of theſe waters chiefly depend on the ſtrength of the ſpirit of wine employed, and eſpecially on its purity from any oil of w[illegible], which gives the diſagreeable ſmell and taſte of common aqua vitæ. *See* SPIRIT (ARDENT).

DCCXXVIII. WATERS (HARD *or* CRUDE). Theſe names are applied to all waters that contain any ſenſible quantity of earth or ſelenites. *See* WATERS (MINERAL). (*t*)

DCCXXIX. WATER (LIME). Lime-water is ordinary water in which quicklime has been ſlaked.

Water in which quicklime has been ſlaked, or with which ſlaked quicklime is waſhed, diſſolves the part of the quicklime that is moſt attenuated, and neareſt to a ſaline ſtate: this ſubſtance, which may be conſidered as ſaline and earthy, communicates to water an alkaline, and ſomewhat acrid taſte. The effects of lime-water in chemical mixtures are ſimilar to thoſe produced by quicklime. *See* QUICK-LIME.

Although lime-water contains no volatile principle, it ought nevertheleſs to be preſerved in full and well cloſed bottles: otherwiſe the ſaline earthy matter diſſolved in it, to which it owes all its peculiar properties, would be ſeparated from it, in proportion as the water ſhould be evaporated, and would appear on the ſurface in form of a cruſt, called *cream of lime*. The quantity of calcareous matter that is thus ſeparated from lime-water, is even greater than it ought to be, if it was exactly proportionate to the evaporation of the water. The cauſe of which probably is, that the firſt portions of this matter which cryſtallize, draw along with them another part that would otherwiſe have remained diſſolved in the water. Hence lime-water, by long expoſure to air, loſes much of its ſtrength, and at laſt becomes almoſt inſipid. *See a note ſubjoined to the article* QUICK-LIME.

(*t*) *Hard waters* are thoſe in which ſoap does not diſſolve uniformly, but is curdled. The diſſolving power of hard water is leſs than that of *ſoft*; and hence its unfitneſs for bleaching, dyeing, boiling leguminous vegetables, and for many other purpoſes of economy and arts. One cauſe of the hardneſs of water is, that it contains ſome ſalt that may be decompoſed by ſoap, the alkali of which uniting with the acid of the ſalt, the oil of the ſoap ſeparates, and the ſoap is ſaid to be curdled. Hardneſs of water proceeding from this cauſe may be diſcovered and cured by adding ſome drops of a ſolution of fixed alkali. The ſalts capable of rendering water hard, are not only ſelenites, which is a very frequent cauſe of the hardneſs of water, but any other earthy or metallic ſalt that may be contained in the water, as all theſe are capable of being decompoſed by fixed alkali. Such are the marine ſalt with baſis of magneſia, or of calcareous earth, vitriolic ſalt with baſis of magneſia called Epſom ſalt, green vitriol, and a nitrous ſalt with earthy baſis, to which Dr. Home attributes the hardneſs of ſeveral waters examined by him. The hardneſs of water has been by ſome perſons attributed to common ſalt. But Dr. Home in his *Eſſay on Bleaching* has ſhewn, that neither pure common ſalt, nor any other ſalt with baſis of fixed alkali, give any hardneſs to water, but that this quality may be given to water by the common ſalt which is generally ſold, becauſe this contains ſome part of the earthy ſalts of ſea-water, or of the water of ſalt-ſprings.

Fixable air which waters frequently contain, is another cauſe of the hardneſs of water. This air unites with the alkali of ſoap, renders it mild, and thus weakens its union with the oil. *See* AIR FIXABLE, *and* ALKALI (FIXED). This fixable air, by expoſure of the water during ſome time in open veſſels, exhales; by which means, water is rendered ſoft, and any calcareous earth

DCCXXX. WATER (MERCURIAL). This name is given to a ſolution of mercury in nitrous acid, diluted with a greater or leſs quantity of common water.

This liquor produces very good effects, as an eſcharotic, and even as a cauſtic in ſome diſeaſes of the ſkin that are external, local, and eſpecially venereal. Some perſons uſe this mercurial water internally; but as it muſt be a dangerous remedy, it ought not to be employed.

DCCXXXI. WATERS (MINERAL). All waters naturally impregnated with any heterogeneous matter which they have diſſolved within the earth may be called *mineral waters*, in the moſt general and extenſive meaning of that name; in which are therefore comprehended almoſt all thoſe that flow within, or upon the ſurface of the earth: for almoſt all theſe contain ſome earth or ſelenites. But waters containing only earth or ſelenites are not generally called *mineral*, but *hard* or *crude waters*.

Hard waters, when tried by the chemical proofs hereafter to be mentioned for diſcovering the nature of mineral waters, ſhew no marks of an acid or of an alkali, nor of any volatile, ſulphureous, or metallic matters. Waters which contain a diſengaged calcareous earth, change the color of ſyrup of violets to a green; and thoſe that contain ſelenites, being mixed with a ſolution of mercury in nitrous acid, form a turbith mineral; and when a fixed alkali is added, they are rendered turbid, and a white ſediment is precipitated. Theſe waters alſo do not diſſolve ſoap well. From theſe we may know, that any water which produces theſe effects is a hard, earthy, or ſelenitic water.

Although the waters of the ſea, and ſaline ſprings, be not generally enumerated amongſt mineral waters, they might nevertheleſs be juſtly conſidered as ſuch. For beſides earthy and ſelenitic matters, they alſo contain a large quantity of mineral ſalts. We ſhall therefore conſider them as ſuch in this article.

Mineral waters, properly ſo called, are thoſe in which ſpirituous, ſulphureous, ſaline or metallic ſubſtances are diſcovered by chemical trials. As many of theſe waters are employed ſucceſsfully in Medicine, they are alſo called *medicinal waters*.

or iron which may be diſſolved in the water merely by means of this air, as Mr. Cavendiſh and Mr. Lane have ſhewn [*Philoſ. Tranſ.* 1767 *and* 1769.] are precipitated.

By boiling, the hardneſs of water proceeding from fixable air may be cured, but that from earthy or metallic ſalts cannot.

Spring-waters are frequently hard. River water is generally ſoft. The ſmall quantity of earthy ſalts contained in rain and ſnow waters, according to Mr. Margraaf's analyſis, does not ſenſibly render them hard.

As rivers are formed by the junction of many ſprings, the greater hardneſs of the water of the latter ſeems to be not eaſily explicable. Does this difference betwixt theſe two waters proceed from fixable air being contained more copiouſly in ſprings, than in rivers, by the motion and free expoſure of which it is moſtly exhaled? or from a larger quantity of atmoſpherical air being contained in the water of rivers by means of their motion and free expoſure, than in the water of ſprings; as a mixture of atmoſpherical air with water is known to encreaſe the diſſolving power of this liquid? or from both theſe cauſes united?

Mineral waters receive their peculiar principles by paſſing through earths containing ſalts, or pyritous ſubſtances that are in a ſtate of decompoſition. *See* PYRITES.

Some of theſe waters are valuable from the quantity of uſeful ſalts which they contain, particularly of common ſalt, great quantities of which are obtained from theſe waters; and others are chiefly valued for their medicinal qualities.

The former kind of mineral waters is an object of manufacture, and from them is chiefly extracted that ſalt only which is moſt valuable in commerce. *See* WATER *of the* SEA; and WATER *of* SALINE SPRINGS.

But the nature and proportion of all the principles of which medicinal waters conſiſt, ought to be carefully examined. Many of theſe waters have been accurately analyſed by able chemiſts and phyſicians.

But notwithſtanding theſe attempts, we are far from having all the certainty and knowledge that might be deſired on this important ſubject; for this kind of analyſis is perhaps the moſt difficult of any in chemiſtry.

Almoſt all mineral waters contain ſeveral different ſubſtances, which being united with water may form with each other numberleſs compounds. Frequently ſome of the principles of mineral waters are in ſo ſmall quantity, that they can ſcarcely be perceived; although they may have ſome influence on the virtues of the water, and alſo on the other principles contained in the water.

The chemical operations uſed in the analyſis of mineral waters, may ſometimes occaſion eſſential changes in the ſubſtances that are to be diſcovered. And alſo, theſe waters are capable of ſuffering very conſiderable changes by motion, by reſt, and by expoſure to air.

Probably alſo the variations of the atmoſphere, ſubterranean changes, ſome ſecret junction of a new ſpring of mineral or of pure water; laſtly, the exhauſtion of the minerals whence waters receive their peculiar principles, are cauſes which may occaſionally change the quality of mineral waters.

We need not therefore wonder that the reſults of analyſes of the ſame mineral waters made by different chemiſts, whoſe ſkill and accuracy are not queſtioned, ſhould be very different.

The conſequences of what we have ſaid on this ſubject are, that the examination of mineral waters is a very difficult taſk; that it ought not to be attempted but by profound and experienced chemiſts; that it requires frequent repetitions, and at different times; and laſtly, that no fixed general rules can be given concerning theſe analyſes.

As this matter cannot be thoroughly explained without entering into details connected with all the parts of chemiſtry, we ſhall here mention only the principal reſults, and the moſt eſſential rules, that have been indicated by the attempts hitherto made on this ſubject.

We may admit the diviſion or arrangement of mineral waters into certain claſſes, propoſed by ſome of the beſt chemiſts and naturaliſts.

Some of theſe waters are called *cold*, becauſe they are not naturally hotter than the atmoſphere. Some of them are even colder, eſpecially in ſummer.

Thoſe are called *hot mineral waters*, which in all ſeaſons are hotter than the air. Theſe are of various degrees of heat, and ſome of them are almoſt as hot as

boiling water. In ſome mineral waters certain volatile, ſpirituous and elaſtic principles may be perceived, by a very ſenſible piquant taſte; this principle is called the *gas* or the *ſpirit of waters.*

The waters which contain this principle are generally lighter than pure water. They ſparkle and emit bubbles, at their ſpring, but eſpecially when they are ſhook, and poured from one veſſel into another. They ſometimes break the bottles containing them, when theſe are well corked, as fermenting wines ſometimes do. When mixed with ordinary wine, they give to it the piquancy and ſparkling quality of Champaigne wine.

This volatile principle and all the properties of the water dependant upon it are loſt merely by expoſure to air. The waters containing this principle are diſtinguiſhed by the name of *ſpirituous mineral waters.*

Other diviſions of mineral waters may be made, relatively to ſome of their predominant principles. Hence ſome waters are called *acidulous*, *alkaline*, *martial*, *neutral*, &c.

When a mineral water is to be examined, we may obſerve the following rules:

Experiments ought to be made near the ſpring, if poſſible.

The ſituation of the ſpring, the nature of the ſoil, and the neighbouring riſing grounds ought to be examined.

Its ſenſible qualities, as its ſmell, taſte, color, are to be obſerved.

Its ſpecific gravity and heat are to be aſcertained by the hydroſtatical balance and the thermometer.

From the properties above-mentioned of ſpirituous mineral waters, we may diſcover whether it be one of this claſs. For greater certainty we may make the following trial. Let the neck of a wet bladder be tied to the neck of a bottle containing ſome of this water. By ſhaking the water, any *gas* that it may contain will be diſengaged, and will ſwell the bladder. If the neck of the bladder be then tyed with a ſtring above the bottle, and be cut below this ſtring, ſo as to ſeparate the bladder from the bottle, the quantity and nature of the contained *gas* may be further examined.

Laſtly, we muſt obſerve the changes that are ſpontaneouſly produced upon the water in cloſe and in open veſſels, and with different degrees of heat. If by theſe means any matter be cryſtallized or depoſited, it muſt be ſet apart for further examination.

Theſe preliminary experiments and obſervations will almoſt certainly indicate, more or leſs ſenſibly, ſomething concerning the nature of the water, and will point out the method to be followed in our further inquiry.

We muſt then proceed to the decompoſition of the water either without addition and merely by evaporation and diſtillation, or with the addition of other ſubſtances, by means of which the matters contained in the water may be precipitated, and diſcovered. It is not material which of theſe two methods be firſt practiſed, but it is quite neceſſary that the one ſhould ſucceed the other. If we begin by evaporating and diſtilling, theſe operations muſt be ſometimes interrupted, that the ſeveral principles which riſe at different times of the diſtillation may be obtained and examined ſeparately, and alſo to allow the ſeveral ſalts that may be contained, to cryſtallize by the evaporation and by cold. *See* EVAPORATION, DISTILLATION, *and* CRYSTALLIZATION.

The

The ſubſtances generally found in mineral waters, are almoſt always combinations of vitriolic acid, and thoſe of marine acid, together with the ſeveral matters that theſe acids are capable of diſſolving.

The following combinations of vitriolic acid are found in mineral waters.

1. *Volatile ſulphureous acid.* This is ſeldom found, both becauſe it eaſily loſes its phlogiſton, and becauſe it muſt almoſt always meet with ſome ſubſtance that it is capable of diſſolving.

2. *Sulphur.* This is found ſometimes ſingly, but generally in form of a liver of ſulphur. In theſe waters, ſulphur is formed into a hepar by means of calcareous earth, or of mineral alkali.

3. *Vitriolic ſalts with earthy baſes.* Theſe ſalts are almoſt always *ſelenitic*, that is, their acid is combined with a calcareous earth. Sometimes, but not ſo frequently, they are *aluminous*, when their acid happens to be united with an argillaceous earth.

4. *Vitriols. Martial vitriol* is frequently contained in mineral waters; *vitriol of copper* is ſometimes but ſeldom, and *vitriol of zinc* is ſtill more rarely found in theſe waters. The vitriols of other metallic ſubſtances are ſcarcely ever, but in very ſingular caſes, found in water.

5. Laſtly, *vitriolic ſalts with baſis of fixed alkali.* This is always *Glauber's ſalt.* Neither *vitriolated tartar* nor *vitriolic ammoniacal ſalt* are ever found, unleſs by ſome ſingular accident, in mineral waters.

The combinations of marine acid that are contained in mineral waters are *common ſalt*, and *marine ſalt with earthy baſis.* For no combinations of this acid with phlogiſton are known, and it is very ſeldom found united with any metallic ſubſtance.

Compounds formed of the nitrous acid are, in a manner, ſubſtances extraneous to the mineral kingdom, ſince this acid is never produced but upon the ſurface of the earth, and from vegetable and animal matters. *See* Acid (Nitrous) *and* Nitre. This acid cannot therefore be found in waters but very accidentally.

Theſe are the principal ſubſtances that form almoſt all theſe waters. We ſhall now ſhew the proofs by means of which they may be diſcovered in water, without decompoſing the water by evaporation or by diſtillation.

If any portion of diſengaged acid or alkali be contained in water, it may be known by the taſte, by changing the color of violets or of turnſol, and by adding the preciſe quantity of acid or of alkali that is neceſſary for the ſaturation of the contained diſengaged ſaline matter.

Volatile ſulphureous acid, ſulphur, and liver of ſulphur, may be diſcovered in waters by their ſingular ſmell, by the black color which theſe ſubſtances give to white metals or to their precipitates, but eſpecially to ſilver.

Vitriolic ſalts with earthy baſis may be diſcovered in water by two proofs: 1. By adding ſome fixed alkali, which decompoſes all theſe ſalts, and precipitates their earthy baſis; and, 2. By adding a ſolution of mercury in nitrous acid, which alſo decompoſes theſe ſalts, and forms a *turbith mineral* with their acid.

Martial vitriol or iron combined with any acid, ſhews itſelf in waters by blackening an infuſion of galls, or by forming a Pruſſian blue with the phlogiſticated alkaline lixivium.

The vitriol of copper, or copper diſſolved by any acid, may be diſcovered by adding ſome of the volatile ſpirit of ſal ammoniac, which produces a fine blue color, or by the addition of clean iron, upon the ſurface of which the copper is precipitated in its natural or metallic ſtate.

Glauber's ſalt is diſcovered by adding a ſolution of mercury in nitrous acid, and forming with it a turbith mineral; or by cryſtallization.

Common ſalt contained in waters forms with a ſolution of ſilver in nitrous acid a white precipitate, or luna cornea. It may alſo be known by its cryſtallization. Marine ſalt with earthy baſis produces the ſame effect upon ſolution of ſilver. It alſo forms a precipitate when fixed alkali is added. The acrimony, bitterneſs, and deliqueſcency of this ſalt ſerve to diſtinguiſh it.

The proofs related for the examination of mineral waters are only thoſe which are moſt eſſential. Many others may be made to confirm the former proofs: but the details of theſe are too extenſive to be inſerted here. We ſhall add only two of theſe, becauſe they are very general, and may be very uſeful.

The firſt is the production of artificial ſulphur, or of the volatile ſulphureous acid; by which means the vitriolic acid may be diſcovered in any combination whatever. For this purpoſe the matter to be examined muſt be mixed with any inflammable ſubſtance, and expoſed to a red heat. If this matter contained but a particle of vitriolic acid, it would be rendered ſenſible by the ſulphur, or by the volatile ſulphureous acid thence produced. *See* SULPHUR.

The ſecond general proof for mineral waters which we ſhall mention here ſerves to diſcover any metallic ſubſtance whatever, diſſolved in water by any acid. This proof conſiſts in adding ſome of the liquor ſaturated by the coloring matter of Pruſſian blue, diſcovered and deſcribed by Mr. Macquer in his Memoir upon Pruſſian Blue. This liquor produces no effects upon any neutral ſalts with earthy or alkaline baſes, but decompoſes all metallic ſalts: ſo that if no precipitate be formed upon adding ſome of this liquor, we may be certain that the water does not contain any metallic ſalt; and on the contrary, if a precipitate is formed, we may certainly infer that the water does contain ſome metallic ſalt.

Two kinds only of *gas*, or the ſpirituous volatile part of ſome waters, are hitherto known; of which one is the volatile ſulphureous acid, and the other is pure air, as Mr. Venel has ſhewn in the waters of Sel or Selters. Air united ſuperabundantly with ſpirituous waters is the chief cauſe of their lightneſs, piquancy, and ſparkling.

When the nature and quantities of the principles contained in a mineral water are aſcertained by ſuitable experiments, it is very proper to attempt to imitate artificially this water, by adding to pure water the ſame proportions of the ſame ſubſtances, as Mr. Venel has done in examining ſeveral waters, eſpecially that of Selters.

We may eaſily perceive the neceſſity of uſing no veſſels in theſe experiments, but ſuch as are perfectly clean and rinſed with diſtilled water; of weighing the products of the experiments very exactly; of making the experiments upon as large quantities of water as is poſſible, eſpecially the evaporations, cryſtallizations, and diſtillations; and of repeating all experiments ſeveral times. We may further obſerve, that the mixtures from which any precipitates might be expected,

expected, ought to be kept two or three days, becaufe many of thefe precipitates require that time or more to appear, or to be entirely depofited.

We fhall now endeavor to explain how mineral waters become impregnated with their principles.

The *felenitic* parts of water are received by this fluid while it flows through gypfeous earths and ftones, thefe being compofed of felenites, which is foluble in water.

The mines of fal gem which are in many places, and particularly where falt-fprings are, furnifh the waters which flow through them, and perhaps the fea itfelf, with the *common falt* that they contain.

When a water once contains common falt, it may become impregnated with *Glauber's falt* by paffing through clay; the vitriolic acid that is always contained in argillaceous earths, decompofing a part of the common falt of the water, with the bafis of which it forms the Glauber's falt; while the marine acid now difengaged will unite with the firft calcareous particles that it meets, and form a *marine falt with earthy bafis*, which is accordingly always found in fea-water, and in falt-fprings.

When water impregnated, or not, with faline principles flows through parts of the earth containing pyrites in a ftate of decompofition, it becomes impregnated with *fulphur*, with *martial vitriol*, with *vitriol of copper*, with *alum*, and with *other falts*; and frequently with feveral of thefe fubftances at the fame time, according to the nature of the pyrites. *See* PYRITES.

The *heat of hot mineral waters* can be only acquired by wafhing large maffes of pyrites and other fimilar minerals in a ftate of fpontaneous decompofition, during which they always acquire confiderable heat.

Laftly, the aerial *gas* of fome mineral waters may have been difcharged from fome of the principles with which the water is impregnated, which were in the act of combination with each other at the time they were diffolved by the water, or which were combined after this folution. For we know that in almoft all folutions much air is extricated; and this air being well divided and diffufed among the particles of water, adheres to them, and in fome meafure combines with them fuperabundantly. Mr. Venel has made upon this fubject a fine experiment, that proves the truth of the above-mentioned theory, which was firft given by him. He added to common water as much marine acid and mineral alkali as were fufficient to form as much common falt as is contained in the mineral water of Selters. He corked very well the bottle containing this impregnated water. The combination proceeded flowly and without effervefcence, becaufe the faline matters were much diluted; and when the combination was completed, the artificial water was become fpirituous and aerial, like the natural water that he imitated. *See the particular articles of all the fubftances mentioned that relate to mineral waters; from a knowledge of the properties of which fubftances many explanations on this fubject may be deduced, too long to be here inferted.* (*u*)

(*u*) The *gas* which gives the fparkling and inebriating qualities to many mineral waters, feems not to differ from the vapor extricated from effervefcing and fermenting fubftances, called *fixable air*. *See* AIR (FIXABLE). The Honourable Mr. Cavendifh has added to his former important difcoveries concerning fixable air, one that throws much light on the nature

DCCXXXII. WATERS (MOTHER). This name is given to the liquor that remains after as much of the saline substances contained in a water has been separated as can be by the usual methods, evaporation and cooling, and from which therefore no more crystals can be obtained, without much difficulty, though it still remains impregnated with salts. These mother-waters are very different, according to the kinds of salts with which the waters were originally impregnated. They are generally very heavy, acrid, and red.

The nature of mother-waters was a long time very imperfectly understood. They were considered as liquors loaded with greasy and viscid matters, by means of which the salts contained were prevented from crystallizing.

A portion of crystallizable salt, similar to those already extracted, does indeed remain in the mother-waters; and perhaps also the crystallization of these may be impeded by the viscid matters that are sometimes contained in these waters: but generally the greatest part of the matter contained in mother-waters is

nature of many mineral waters. This discovery is, that by means of fixable air, and without the intervention of any acid, calcareous earth is dissolved in some mineral waters. He found that the quantity of this air that was contained in Rathbone-place-water, relatively to the quantity of calcareous earth contained in that water, was about twice as much as is usually combined with an equal quantity of calcareous earth; and that the earth might be precipitated from this water by driving off the fixable air by heat, or by absorbing it by the addition of lime-water. Does not this solution of calcareous earth by fixable air confirm a conjecture concerning the analogy of this vapor with acids? It seems very extraordinary that calcareous earth saturated with its usual quantity of air should be unsoluble in water, but that it may be rendered soluble, either by depriving it entirely of this air, as it is in lime-water, or by uniting it with a superabundant quantity of air, as it is in the water of Rathbone-place. *See Phil. Trans. for the Year* 1767.

Mr. Lane has discovered another instance of the dissolving power of fixable air upon iron, and has, by some ingenious experiments, shewn the probability that this metal is dissolved in many mineral waters by means only of that air. He found that pure distilled water, having been impregnated with the fixable air arising from effervescing or fermenting substances, was rendered capable of dissolving a sensible portion of iron; and that this artificial chalybeate water, by exposure to air, lost entirely its property of tinging an infusion of galls. As several chalybeate mineral waters do also, by exposure to air, entirely lose their property of tinging an infusion of galls; and as waters containing iron dissolved by means of vitriolic acid, though a considerable sediment is also deposited from them, do never entirely lose this property; he infers, that the former kind of waters receive their chalybeate impregnation by means, not of an acid, but of this air. He further shews, from experiments, that iron cannot be so entirely precipitated from its solution in any of the mineral acids by means of mild alkalis, or mild calcareous earth, that this solution shall lose its power of tinging an infusion of galls; but that the iron may be so perfectly precipitated from the above-mentioned solutions by means of caustic alkali, or of lime-water; and hence he infers, that in the former case the portion of iron that is not precipitated is kept suspended or dissolved by means of the fixable air extricated by the acid of the solution from the mild alkali or earth. *See Phil. Trans. for the Year* 1769.

In the above article concerning mineral waters, the Author of the Dictionary considers nitre or nitrous acid as substances not to be found in native waters, but by some accidental occurrence. Nevertheless, from the experiments of Mr. Margraaf on the waters of the wells at Berlin, of Dr. Heberden on those of London, and of Dr. Home on those of some wells in Scotland, we have reason to believe, that true nitre and a nitrous salt with earthy basis are frequently contained in waters of springs, especially in towns.

composed

composed of salts that are deliquescent and different from those already obtained by crystallization. We are certain, at least, that the mother-waters of sea-salt and of nitre are formed almost entirely of these salts, which have a certain kind of adhesion to the crystallizable salts, and which therefore prevent the crystallization of the last portions of these. The mother-water of common salt contains a considerable quantity of marine salt with earthy basis, and the mother-water of nitre contains not only marine salt with earthy basis, but also a considerable quantity of nitre with earthy basis: hence, if a fixed alkali be added to these waters, a white earthy precipitate is formed so copiously, that the whole becomes a kind of paste. By diluting this paste with much water, the earth may be obtained by filtration. The earth when edulcorated is very white, and of a calcareous nature. It is called *magnesia*. (*x*)

If vitriolic acid be added to these mother-waters, a very copious white precipitate is likewise formed. This precipitate also proceeds from the union of this acid with the calcareous earth of the earthy salts, by which a selenites is formed. This selenites, not being soluble in so small a quantity of water as that of the mother-water employed, is mostly precipitated in form of an earthy sediment consisting of very minute crystals. *See* SALTS *with* EARTHY BASIS, *and* MAGNESIA.

DCCXXXIII. WATER *of* RABEL. The water of Rabel is vitriolic acid dulcified by mixture with rectified spirit of wine. Rabel, the inventor of this liquor, which is used in medicine, employed an expensive apparatus in the preparation of it. He obtained the vitriolic acid from pyrites: but since his time, the process has been much simplified, as it ought to be. One part of oil of vitriol is mixed with three parts of rectified spirit of wine, and the mixture is digested in a well-closed vessel. The vitriolic acid acts upon all the principles of the spirit of wine, and combines with them in a certain degree during this digestion: hence the acidity of the liquor is considerably diminished, but not perfectly destroyed. This water of Rabel may be considered as a dulcified vitriolic acid. *See* ETHER.

Water of Rabel is employed in medicine as an astringent, from the property which the vitriolic acid has of constringing the fibres and vessels. It requires to be diluted in some proper vehicle, as in potions or juleps.

DCCXXXIV. WATER (SEA). Sea-water, and the waters of many salt-lakes, wells, and springs, containing various kinds of salts, is in much greater quantity than fresh-water.

We may say in general, that all natural salt-waters contain four kinds of salts, namely, common salt, Glauber's salt, selenites, and marine salt with earthy basis. These salts are in different quantities and proportions, according to the nature of the waters; but the quantity of the common salt is always greater than that of any other.

(*x*) Magnesia is an earth not convertible into quicklime, therefore different from calcareous earth, with which the Author of the Dictionary confounds it, and is possessed of peculiar properties. *See the article* MAGNESIA, *and the* NOTE *subjoined*. The mother-waters of common salt and of nitre do also contain some marine and nitrous salts with basis of calcareous earth, as appears from the formation of selenites upon adding vitriolic acid, as is mentioned in the following paragraph of the text.

All theſe waters have a ſaline, and more or leſs of an acrid, bitter taſte. The acrimony and bitterneſs of theſe waters are generally attributed to bituminous matters ſuppoſed to be contained in them: but I can affirm, that I have made many experiments on large quantities of theſe ſeveral waters, and that I could never find any ſenſible quantity of bitumen. The bitterneſs, therefore, of theſe waters ought to be attributed to the Glauber's ſalt, which is bitter, and eſpecially to the marine ſalt with earthy baſis, which is very bitter and acrid.

Sea-water is not every-where impregnated with an equal quantity of ſalt. Generally, it has been obſerved to contain more ſalt in hot than in cold climates. The quantity of common ſalt contained in ſea-water is to the quantity of that water as three or four to a hundred. The water is conſequently far from being ſaturated with that ſalt; for water is capable of diſſolving nearly a fourth part of its weight of common ſalt.

Common ſalt is obtained from ſea-water by evaporation alone, and not by alternate evaporation and cooling; becauſe this ſalt is equally ſoluble in cold as in hot water. *See* CRYSTALLIZATION, *and* SALT (COMMON).

In the ſouthern provinces of France, and in all equally hot or hotter climates, ſea-water is evaporated in open air, and merely by the heat of the ſun in ſummer, by which means the common ſalt is obtained. For this purpoſe, large baſons are made in the ground near the ſea, called ſalt-marſhes. They are ſo diſpoſed that the ſea-water may flow into them at certain tides, and be retained there. Theſe marſhes are divided into many compartments, communicating with each other, into which any required quantity of water may be admitted. The water in theſe is of a ſmall depth, that the evaporation may advance more quickly. When the water is ſufficiently evaporated, and the ſalt is cryſtallized, more water is admitted, till a ſufficient quantity of ſalt is obtained, which is then gathered in heaps and drained.

In the northern provinces of France common ſalt is obtained from ſea-water in the following manner:

A quantity of ſand moiſtened with ſea-water is expoſed to the ſun and dried, which is quickly done, becauſe the ſea-water is almoſt entirely near the ſurface of the ſand. The ſand, which then becomes covered with a conſiderable quantity of ſalt, is to be waſhed with as much water as is neceſſary for the ſolution of the ſalt adhering to it; and this water is afterwards evaporated over the fire in leaden cauldrons, till the ſalt is cryſtallized.

Wallerius ſays, that in northern countries the ſalt in ſea-water is concentrated by expoſure to intenſe cold, by which great part of the water is frozen, and the unfrozen part, which contains almoſt all the ſalt, is afterwards evaporated by fire, till the ſalt is cryſtallized.

After the common ſalt has been thus obtained by theſe operations from ſea-water, a liquor, called *mother-water*, remains that contains much ſalt, which cannot be cryſtallized. If this water be further evaporated, and then expoſed to cold, a certain quantity of Glauber's ſalt will be formed, which is very impure and badly cryſtallized, and is generally called *Epſom ſalt*. *See* SALT (EPSOM). (*y*)

(*y*) The ſalt called *Epſom ſalt*, or ſal catharticus amarus, large quantities of which are obtained from the mother-water remaining after the evaporation of ſea-water, and which

Laſtly, the remaining part of the mother-water contains ſcarcely any thing but marine ſalt with earthy baſis, the earthy part of which may be precipitated by an alkaline lixivium. This earth is called the *Magneſia of common ſalt*. See Water (Mother), *and* Magnesia.

DCCXXXV. WATER *of* SALT-SPRINGS. The water of almoſt all ſalt ſprings, at leaſt of thoſe from which common ſalt is obtained, contains exactly the ſame principles as ſea-water, but generally in a larger quantity. Some of theſe ſprings contain ſixteen pounds of ſalt in a hundred pounds of water. Such, for inſtance, is that of Dieuſe in Lorraine, one of the beſt ſalt-works known. Other ſprings contain a much ſmaller proportion of ſalt; ſuch is that of Montmorot in Franche-compté.

Salt is obtained from theſe ſalt-ſprings generally by evaporation over the fire; at leaſt, it is ſo in Lorraine, and in Franche-compté: but that the expence of fuel may be leſſened, the water, when weakly impregnated, is previouſly concentrated by frequently pouring it upon bundles of twigs or faggots under buildings that are covered, but open at all the ſides, called *graduating houſes*. The water raiſed by pumps to the top of theſe buildings falls upon the faggots, by which it is divided into a ſhower, its ſurface is thereby encreaſed, and the evaporation is promoted by the free current of air that paſſes through the open ſides of the building. When, by this means, the water is ſo concentrated that a hundred pounds of it contain about thirteen or fourteen pounds of ſalt, it is then evaporated over the fire in the uſual manner.

As theſe waters are much more impregnated with ſaline principles than ſea-water, and as their evaporation is more quickly finiſhed, we ſhall confirm what we have ſaid concerning the evaporation and formation of the ſeveral ſalts in ſea-water, by deſcribing the method employed in the evaporation of the water of the ſalt-ſprings of Lorraine and Franche-compté.

This water is evaporated in very large veſſels made of plates of iron, capable of containing from eight to nine or ten thouſand gallons of water, called *ſalt-pans*, the depth of which is about fifteen or ſixteen inches.

In theſe the water is boiled ſome time, during which a ſaline earthy matter, called *ſchlot or ſcratch*, is depoſited, and is carefully to be ſeparated. This ſcratch is a ſelenites, which of all the ſaline matters contained in the water is the leaſt ſoluble, and conſequently cryſtallizes firſt. This ſelenites draws along with it ſome of the other ſalts, and principally Glauber's ſalt, which ſeems to have ſome degree of adheſion to it.

When the ſelenites is ſeparated, the common ſalt, being in greater quantity than the other ſalts, begins to cryſtallize and form cubes. That larger cryſtals of this ſalt may be formed, the water is made to boil very ſlowly, till the common ſalt ceaſes to cryſtallize. The water that remains is very heavy, much impregnated with ſalt, of an acrid and bitter taſte. This is the *mother-water*.

This mother-water contains ſtill ſome common ſalt, ſome Glauber's ſalt, and eſpecially a large quantity of marine ſalt with earthy baſis. The Glauber's

which is ſimilar to the ſalt obtained by evaporation of the mineral water at Epſom, is compoſed of vitriolic acid and magneſia; it is therefore improperly ſaid to be Glauber's ſalt, which conſiſts of vitriolic acid united with mineral alkali, although ſome of this latter ſalt alſo is ſaid to be contained in ſea-water.

salt remains chiefly in the mother-waters, because it is much more soluble in hot than in cold water, and crystallizes more readily by cold than by evaporation. The marine salt with earthy basis remains almost entirely in the mother-water, because it is deliquescent, and not susceptible of a true crystallization. *See* WATER (MOTHER).

The several salts contained in waters of salt-springs are thus separated from each other: but this separation is not very accurate. To render it more compleat, other means must be employed. The fundamental principles of the perfect purification of the several salts confounded together in the same water are explained at the article CRYSTALLIZATION. To avoid repetitions, we refer to that article. *See also the articles* SELENITES, SALT (COMMON), SALT *of* EPSOM, SALT *of* GLAUBER, SALT (MARINE) *with* EARTHY BASIS, WATER (MOTHER), *and* WATERS (MINERAL).

DCCXXXVI. W A X. Wax is an oily, concrete matter gathered by bees from plants.

Wax has been long considered as a resin, from some properties common to it with resins. It has the same consistence as resins have, and, like them, it furnishes an oil and an acid by distillation, and is soluble in all oils: but in several respects it differs sensibly from resins. Like these, wax has not a strong aromatic taste and smell, but a very weak smell, and, when pure, no taste. With the heat of boiling water no principles are distilled from it; whereas, with that heat, some essential oil, or, at least, a spiritus rector is obtained from every resin. Further, wax is unsoluble in spirit of wine. If wax be distilled with a heat greater than that of boiling water, it may be decomposed, but not so easily as resins can. By this distillation a small quantity of water is first separated from the wax, and then some very volatile and very penetrating acid, accompanied with a small quantity of a very fluid and very odoriferous oil. As the distillation advances, the acid becomes more and more strong, and the oil more and more thick, till its consistence be such that it becomes solid in the receiver, and is then called *butter of wax*. When the distillation is finished, nothing remains but a small quantity of coal, which is almost incombustible from the want of some saline matter. *See* COAL.

Wax cannot be kindled, unless it be previously heated and reduced into vapors; in which respect it resembles fat oils. The oil and butter of wax may, by repeated distillations, be attenuated and rendered more and more fluid, because some portion of acid is thereby separated from these substances; which effect is similar to what happens in the distillation of other oils and oily concretes: but this remarkable effect attends the repeated distillation of oil and butter of wax, that they become more and more soluble in spirit of wine; and that they never acquire greater consistence by evaporation of their more fluid parts. Boerhaave kept butter of wax in a glass vessel open, or carelessly closed, during twenty years, without acquiring a more solid consistence. We may remark, that wax, its butter, and its oil, differ entirely from essential oils and resins in all the above-mentioned properties, and that in all these they perfectly resemble sweet oils. *See* OILS (ESSENTIAL), RESINS, *and* OILS (SWEET EXPRESSED).

We may therefore conclude from what has been said, as Mr. Macquer has done in his Elements of Chemistry, and in his Memoir upon Oils, that wax only

only resembles resins in being an oil rendered concrete by an acid; but that it differs essentially from these in the kind of the oil, which in resins is of the nature of essential oils, while in wax and in other analogous oily concretions, (as butter of milk, butter of cocoa, fat of animals, sperma-ceti, and a wax obtained from a tree in Louisiana) it is of the nature of sweet, unctuous oils that are not aromatic and not volatile, and are obtained from vegetables by expression.

Wax is very useful, especially as a better material than any other for candles.

Wax may be deprived of its natural yellow disagreeable color, and be perfectly whitened, by exposure to the united action of air and of water, by which method the color of many substances may be destroyed.

The art of bleaching wax consists in encreasing its surface. For which purpose, it must be melted with a degree of heat not sufficient to alter its quality, in a cauldron so disposed that the melted wax may flow gradually through a pipe at the bottom of the cauldron into a large tub filled with water, in which is fitted a large wooden cylinder, that turns continually round its axis, and upon which the melted wax falls. As the surface of this cylinder is always moistened with cold water, the wax falling upon it does not adhere to it, but quickly becomes solid and flat, and acquires the form of ribbands. The continual rotation of the cylinder carries off these ribbands as fast as they are formed, and distributes them through the tub. When all the wax that is to be whitened is thus formed, it is put upon large frames covered with linen cloth, which are supported about a foot and a half above the ground, in a situation exposed to the air, the dew, and the sun. The thickness of the several ribbands, thus placed upon the frames, ought not to exceed an inch and a half; and they ought to be moved from time to time, that they may all be equally exposed to the action of the air. If the weather be favorable, the color will be changed in the space of some days. It is then to be re-melted and formed into ribbands, and exposed to the action of the air as before. These operations are to be repeated till the wax be rendered perfectly white, and then it is to be melted into cakes, or formed into candles.

The yellow color of the wax is evidently destroyed by the combined action of the air, of the water, and of the sun. As the volatile, sulphureous acid has the property of destroying still more quickly almost all the colors of vegetables, perhaps this bleaching might be shortened by exposing ribbands of yellow wax to the vapor of sulphur, as is practised for wool and silk.

Every kind of wax is not equally capable of being whitened, the color of some adhering so strongly, that it cannot be effaced. Such is the wax that comes from countries in which vines grow. This observation I have received from Mr. Trudon, proprietor of the manufactory of wax, at Antoni, near Paris.

Wax is employed for many purposes in several arts. It is also used in medicine as a softening, emollient, and relaxing remedy; but it is only used externally, mixed with other substances. It is an ingredient in many pomatums, cerates, ointments, and plasters, to most of which it gives the due consistence. Upon this subject may be consulted Mr. Beaumé's Elements of Pharmacy, a work containing many excellent observations.

DCCXXXVII. W H E Y. *See* Milk.

DCCXXXVIII. W H I T E (S P A N I S H). This name is given to very different ſubſtances, namely, the *magiſtery of biſmuth*, and the waſhed *chalk* uſed for painting in water colors.

DCCXXXIX. W H I T E - L E A D. This name is given to the white ruſt produced by expoſing lead to the vapors of vinegar. It is alſo called *ceruſs*. *See* Ceruss.

DCCXL. W I N E. Chemiſts give the name of *wine* in general to all liquors that have become ſpirituous by fermentation. Thus *cyder*, *beer*, *vinous hydromel*, or *mead*, and other ſimilar liquors, are wines.

The principles and theory of the fermentation which produces theſe liquors are eſſentially the ſame. The more general principles we have explained under the article Fermentation. At the articles Beer and Hydromel may be found ſome peculiarities relative to theſe kinds of wines. In the preſent article we ſhall chiefly attend to the *wine of grapes*, to which the name of *wine* is more particularly applied. At the ſame time, we ſhall not neglect any thing relating to ſpirituous fermentation in general.

All vegetable and animal matters, which have a taſte ſweet, agreeable, and more or leſs ſaccharine, and which are nutritive, are ſuſceptible of the ſpirituous fermentation. Thus wine may be made of all the juices of plants, the ſap of trees, the infuſions and decoctions of farinaceous vegetables, the milk of frugivorous animals, which is poſſeſſed of the above-mentioned qualities; and, laſtly, it may be made of all ripe ſucculent fruits, which alſo are poſſeſſed of theſe qualities: but all theſe ſubſtances are not equally proper to be changed into a good and generous wine.

As the production of ardent ſpirit is the reſult of the ſpirituous fermentation, we may conſider that wine as eſſentially the beſt which contains moſt of this ſpirit. But of all ſubſtances ſuſceptible of the ſpirituous fermentation, none is capable of being converted into ſo good wine, as the juice of the grapes of France, or of other countries that are nearly in the ſame latitude, or in the ſame temperature. The grapes of hotter countries, and even thoſe of the ſouthern provinces of France, do indeed furniſh wines that have a more agreeable, that is, more of a ſaccharine taſte; but theſe wines, though they are ſufficiently ſtrong, are not ſo ſpirituous as thoſe of the provinces near the middle of France: at leaſt, from theſe latter wines the beſt vinegar and aqua vitæ are made. As an example therefore of ſpirituous fermentation in general, we ſhall deſcribe the method of making wine from the juice of the grapes of France.

This juice, when newly expreſſed, and before it has begun to ferment, is called *muſt*, and in common language *ſweet wine*. It is turbid, has an agreeable and very ſaccharine taſte. It is very laxative, and when drank too freely, or by perſons diſpoſed to diarrhæas, it is apt to occaſion theſe diſorders. Its conſiſtence is ſomewhat leſs fluid than that of water, and it becomes almoſt of a pitchy thickneſs when dried.

When the muſt is preſſed from the grapes, and put into a proper veſſel and place, with a temperature from ten or twelve degrees to fifteen or ſixteen, very ſenſible effects are produced in it, in a ſhorter or longer time, according to the nature of the liquor, and the temperature of the place. It then ſwells, and is ſo rarefied, that it frequently overflows the veſſel containing it, if this be

nearly

nearly full. An inteſtine motion is excited among its parts, accompanied with a ſmall hiſſing noiſe and evident ebullition. The bubbles riſe to the ſurface, and, at the ſame time, is diſengaged a vapor which is probably of a phlogiſtic nature, and is ſo ſubtle and dangerous, that it is capable of killing inſtantly men and animals expoſed to it in a place where the air is not renewed. In its effects this vapor is ſimilar to that of burning charcoal. The ſkins, ſtones, and other groſſer matters of the grapes, are buoyed up by the particles of diſengaged air that adhere to their ſurface, are variouſly agitated, and are raiſed in form of a ſcum or ſoft and ſpongy cruſt that covers the whole liquor. During the fermentation this cruſt is frequently raiſed, and broken by the air diſengaged from the liquor, which forces its way through it: afterwards the cruſt ſubſides, and becomes entire as before.

Theſe effects continue while the fermentation is briſk, and at laſt gradually ceaſe: then the cruſt being no longer ſupported, falls in pieces to the bottom of the liquor. At this time, if we would have a ſtrong and generous wine, all ſenſible fermentation muſt be ſtopt. This is done by putting the wine into cloſe veſſels, and carrying theſe into a cellar or other cool place.

After this firſt operation, nature tends ſpontaneouſly to a kind of reſt, as is indicated by the ceſſation of the ſenſible effects of the ſpirituous fermentation; and thus enables us to preſerve a liquor no leſs agreeable in its taſte, than uſeful for its reviving and nutritive qualities when drank moderately.

If we examine the wine produced by this firſt fermentation, we ſhall find that it differs entirely and eſſentially from the juice of grapes before fermentation. Its ſweet and ſaccharine taſte is changed into one that is very different, though ſtill agreeable, and ſomewhat ſpirituous and piquant. It has not the laxative quality of muſt, but affects the head, and occaſions, as is well known, drunkenneſs. Laſtly, if it be diſtilled, it yields, inſtead of the inſipid water obtained from muſt by diſtillation with the heat of boiling water, a volatile, ſpirituous, and inflammable liquor called *ſpirit of wine*, or *ardent ſpirit*. This ſpirit is conſequently a new being, produced by the kind of *fermentation* called the *vinous* or *ſpirituous*. *See* SPIRIT (ARDENT).

As, on one ſide, the liquors ſuſceptible of the ſpirituous fermentation contain chiefly a ſweet oil rendered miſcible with water by means of an acid; and as, on the other ſide, the liquor produced by the ſpirituous fermentation is inflammable, but ſtill miſcible with water, and conſequently compoſed of a watery and inflammable principle; we may eaſily perceive, that the work of nature chiefly conſiſts in attenuating, dividing, and volatiliſing the oily parts of fermentable matters, and in combining theſe intimately with the watery principle. But by what mechaniſm does nature operate this change? In what does this attenuation of the oily part preciſely conſiſt? In what proportion is this oil, or only its inflammable principle, united with the watery principle in the compoſition of ardent ſpirit? Theſe are myſteries of nature that are ſtill entirely hid from us, and which we cannot eaſily explain. Without entering, therefore, into a ſpeculation concerning the production of ardent ſpirit, we ſhall proceed in the hiſtory of ſpirituous fermentation.

When any liquor undergoes the ſpirituous fermentation, all its parts ſeem not to ferment at the ſame time, otherwiſe the fermentation would probably be very quickly compleated, and the appearances would be much more ſtriking: hence,

hence, in a liquor much diſpoſed to fermentation, this motion is more quick and ſimultaneous than in another liquor leſs diſpoſed. Experience has ſhewn, that a wine, the fermentation of which is very ſlow and tedious, is never good and very ſpirituous; and therefore, when the weather is too cold, the fermentation is uſually accelerated by heating the place in which the wine is made. A propoſal, which I think is a good one, has been made by a perſon very intelligent in economical affairs, to employ a greater than the uſual heat to accelerate the fermentation of wine, in thoſe years in which grapes have not been ſufficiently ripened, and when the juice is not ſufficiently diſpoſed to fermentation.

A too haſty and violent fermentation is perhaps alſo hurtful, from the diſſipation and loſs of ſome of the ſpirit: but of this we are not certain. However, we may diſtinguiſh, in the ordinary method of making wines of grapes, two periods in the fermentation, the firſt of which laſts during the appearance of the ſenſible effects above-mentioned, in which the greateſt number of fermentable particles do ferment. After this firſt effort of fermentation, theſe effects ſenſibly diminiſh, and ought to be ſtopped, for reaſons hereafter to be mentioned. The fermentative motion of the liquor then ceaſes. The heterogeneous parts that were ſuſpended in the wine by this motion, and which render it muddy, are ſeparated, and form a ſediment called the lees; after which the wine becomes clear: but although the operation be then conſidered as finiſhed, and the fermentation apparently ceaſes, it does not really ceaſe; and it ought to be continued in ſome degree, if we would have good wine. In this new wine a part of the liquor remains that has not fermented, and which does afterwards ferment, but ſo very ſlowly, that none of the ſenſible effects produced in the firſt fermentation are here perceived. The fermentation, therefore, continues ſtill in the wine, during a longer or ſhorter time, although in an imperceptible manner; and this is the ſecond period of the ſpirituous fermentation, which may be called the *imperceptible fermentation*. We may eaſily perceive, that the effect of this imperceptible fermentation is the gradual encreaſe of the quantity of ſpirit in wine. It has alſo another effect no leſs advantageous, namely, the ſeparation of a ſaline, acid, earthy matter, called *tartar*, from the wine. This matter is therefore a ſecond ſediment that is formed in the wine, and which adheres to the ſides of the containing veſſels. As the taſte of tartar is harſh and diſagreeable, it is evident that the wine, which, by means of the inſenſible fermentation, has acquired more ſpirit, and has diſengaged itſelf of the greateſt part of its tartar, ought to be much better and more agreeable; and for this reaſon chiefly, old wine is univerſally preferable to new wine.

But inſenſible fermentation can only ripen and meliorate the wine, if the ſenſible fermentation has regularly proceeded, and has been ſtopped in due time. We know certainly, that if a ſufficient time has not been allowed for the firſt period of the fermentation, the unfermented matter that remains, being in too large a quantity, will then ferment in the bottles or cloſe veſſels in which the wine is put, and will occaſion effects ſo much more ſenſible, as the firſt fermentation ſhall have been ſooner interrupted: hence theſe wines are always turbid, emit bubbles, and ſometimes break the bottles, from the large quantity of air and vapors that are diſengaged during the fermentation. We have an inſtance of theſe effects in the white wine of Champagne, and in others of the

ſame

ſame kind. The ſenſible fermentation of theſe wines is interrupted, or rather ſuppreſſed, that they may have this ſparkling quality. It is well known that theſe wines make the corks fly out of the bottles, that they ſparkle and froth when they are poured into glaſſes, and, laſtly, that they have a taſte much more lively and more piquant than wines that do not ſparkle; but this ſparkling quality, and all the effects depending on it, are only cauſed by a conſiderable quantity of air which is diſengaged during the confined fermentation which the wine has undergone in cloſe veſſels. This air, not having an opportunity of eſcaping, and of being diſſipated as faſt as it is diſengaged, and being interpoſed betwixt all the parts of the wine, combines in ſome meaſure with theſe, and adheres in the ſame manner as it does to thoſe mineral waters that are called ſpirituous, in which it produces nearly the ſame effects. When this air is entirely diſengaged from theſe wines, they no longer ſparkle, they loſe their piquancy of taſte, become mild, and even almoſt inſipid.

Such are the qualities that wine acquires in time, when its firſt fermentation has not continued ſufficiently long. Theſe qualities are given purpoſely to certain kinds of wine, to indulge taſte or caprice; but ſuch wines ought not to be daily drank. Wines for daily uſe ought to have undergone ſo compleatly the ſenſible fermentation, that the ſucceeding fermentation ſhould be inſenſible, or, at leaſt, exceedingly little ſenſible. Wine, in which the firſt fermentation has been too far advanced, is liable to worſe inconveniences than that in which the firſt fermentation has been too quickly ſuppreſſed; for every fermentable liquor is from its nature in a continual fermentative motion, more or leſs ſtrong, according to circumſtances, from the firſt inſtant of the ſpirituous fermentation, till it is compleatly putrefied: hence from the time of the completion of the ſpirituous fermentation, or even before, the wine begins to undergo the acid or acetous fermentation. This acid fermentation is very ſlow and inſenſible when the wine is included in very cloſe veſſels, and in a cool place; but it does gradually advance, ſo that in a certain time the wine, inſtead of being meliorated, becomes at laſt ſour. This evil cannot be remedied, becauſe the fermentation may advance, but cannot be reverted. Wine-merchants, therefore, when their wines become ſour, can only conceal or abſorb this acidity by certain ſubſtances, as by alkalis and abſorbent earths. But theſe ſubſtances give to wine a dark-greeniſh color, and a taſte, which, though not acid, is ſomewhat diſagreeable. Beſides, calcareous earths accelerate conſiderably the total deſtruction and putrefaction of the wine. Calxes of lead, having the property of forming with the acid of vinegar a ſalt of an agreeable ſaccharine taſte, which does not alter the color of the wine, and which beſides has the advantage of ſtopping fermentation and putrefaction, might be very well employed to remedy the acidity of wine, if lead and all its preparations were not pernicious to health, as they occaſion moſt terrible colics, and even death, when taken internally. We cannot believe that any wine-merchant, knowing the evil conſequences of lead, ſhould, for the ſake of gain, employ it for the purpoſe mentioned; but if there be any ſuch perſons, they muſt be conſidered as the poiſoners and murderers of the public.

If wine contains litharge, or any other calx of lead, it may be diſcovered by evaporating ſome pints of it to dryneſs, and melting the reſiduum in a crucible, at the bottom of which a ſmall regulus of lead may be found after the fuſion:

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but an easier and more expeditious proof is by pouring into the wine some liquid liver of sulphur. If the precipitate occasioned by this addition of the liver be white, or only colored by the wine, we may know that no lead is contained: but if the precipitate be dark-colored, brown, or blackish, we may be certain that lead is contained.

The only substances that cannot absorb or destroy, but cover and render supportable the sharpness of wine, without any inconvenience, are sugar, honey, and other saccharine alimentary matters; but they can succeed only when the wine is but very little acid; and when an exceeding small quantity only of these substances is sufficient to produce the desired effect; otherwise the wine would have a sweetish, tart, and not agreeable taste.

From what we have said concerning the acescency of wine we may conclude, that when this accident happens, it cannot by any good method be remedied, and that nothing remains to be done with sour wine but to sell it to vinegar-makers, as all honest wine-merchants do. We may observe, that the first sensible fermentation having been too far advanced, is not the only cause of the acidity of wine, but that heat also is capable of producing the same effect. Thus wine, which might have been long preserved in a cool place, very quickly becomes sour, when placed in a bad cellar; and even as the best cellars have during winter a degree of heat much superior to that of the atmosphere, it would be very proper, when wine disposed to become sour is to be preserved, to bring it from the cellar in the beginning of winter, and leave it exposed to the air during all that season.

Wine is also liable to other changes; as, to become ropey and mucilaginous, by the continuance of the fermentative motion: but we cannot prosecute these details in a work of this kind. Besides, the spirituous fermentation and its consequences still require a further examination, which we hope will be performed in a satisfactory manner, since several Academies, sensible of the importance of the subject, have offered prizes for discoveries relative to it. All that we can at present say is, that the fundamental principles from which we may deduce a more accurate knowledge on this subject, may be discovered by determining with what degree of heat, and during what time, the first sensible fermentation of must ought to be promoted, that the most spirituous and best-keeping wine may be obtained. I confess that this object is very extensive, and very difficult to be known in a general manner, considering how variable these things are, and what differences, perhaps greater than we now imagine, there ought to be, according to the nature of the must, which varies exceedingly in different countries, and at different times. Experience and observation have already instructed makers of wine in many things relative to this subject; but much yet remains to be determined, which is not within the reach of ordinary country-people, or even of the proprietors of the great vine-yards.

Wine, and the matters produced from wine, as brandy, spirit of wine, vinegar, lees of wine, tartar, are greatly and extensively useful. The lees of wine are employed in the manufacture of hats. These lees, and also tartar by incineration, yield a larger quantity than any other vegetable matter of pure fixed alkali. *See the articles* AQUA VITÆ, SPIRIT *of* WINE, TARTAR, *and* VINEGAR.

Wine

Wine has been preferred in all times and in all countries to every other alimentary liquor. We may ſay in general, that it is good and ſalutary when taken in ſmall quantities, and that it is pernicious when drank habitually, and in too large quantities. Wine becomes then a true ſlow poiſon, which is ſo much more dangerous, as it is more agreeable. But if we obſerve more particularly the effects of wine, we ſhall perceive very great differences depending on different conſtitutions. Some perſons drink habitually large quantities of pure wine, without any ſenſible inconvenience, or diſeaſe, or ſhortening their lives: but, on the contrary, many others do alſo entirely deſtroy their health, and ſhorten their lives, by an habitual uſe of wine even in ſmall quantity, and mixed with water. Although it is always more ſafe and prudent for every perſon to drink little of it habitually, this moderation is more indiſpenſably neceſſary to thoſe whoſe conſtitutions wine does not ſuit.

As the diſeaſes conſequent upon the too free uſe of wine come gradually and inſenſibly, ſometimes even during many years, ſeveral perſons, eſpecially men, otherwiſe very ſober and attentive to health, are every day deceived upon this article, drinking more wine than is ſuitable to their conſtitution, and gradually ruining their health without knowing the cauſe. It is therefore a matter of importance to ſhew the ſigns by which wine may be known to be hurtful. We may know that wine does not ſuit a perſon, when, after drinking moderately of it, his breath acquires a vinous ſmell; when it occaſions ſour belchings and ſlight pains in the head; and when, after drinking it more copiouſly than uſual, it produces ſtupefaction, nauſea, and drunkenneſs, eſpecially when this drunkenneſs is of the moroſe, peeviſh, quarrelſome, and iraſcible kind. Unhappy is that perſon who ſuffers theſe effects from wine, and notwithſtanding contracts and perſiſts in the habitual uſe of it. Theſe imprudent perſons do never fail of coming to a miſerable death, preceded by languor, and premature; their common age being about fifty years, or a little more. The diſeaſes to which they are moſt ſubject are obſtructions in the liver, in the meſenteric glands, and in other abdominal viſcera, which are almoſt always ſucceeded by an incurable dropſy. Thoſe who digeſt wine well, do not ſuffer, or much leſs ſenſibly, the above-mentioned effects of drinking it. Their drunkenneſs is accompanied with vivacity and joy. Such perſons ſeldom die of the obſtructions and dropſy above-mentioned: but wine is nevertheleſs ſo much more dangerous to them, that as they ſuffer none of the diſagreeable effects, they are more liable to contract the habit of drinking too much. Drinkers of this claſs generally live ſomewhat longer than the former; but their conſtitution generally changes before ſixty years of age; and the inheritance of their old age is either a ſevere gout or palſy, ſtupidity, imbecillity, or an accumulation of theſe diſeaſes.

We need not mention that the too frequent uſe of brandy, ratafia, and of other ſpirituous liquors is ſtill much more pernicious and fatal than of wine.

Wine is uſed in medicine as a vehicle in the compoſition of many internal and external remedies. As wine is compoſed of an ardent ſpirit, water, extractive ſaponaceous matter, and acid of tartar, it may be very uſefully employed for the extraction of almoſt all the proximate principles, and conſequently of the medicinal parts, of vegetables. Many extracts are made with wine, which may be conſidered as being more compleat than thoſe made with water: but phyſicians who preſcribe theſe extracts ought to remember that, beſides

the principles of the vegetables, they also contain the extractive part of wine, that is, all the principles of wine, excepting the ardent spirit, which is too volatile to remain in an extract.

As wine, when good, may be preserved during a long time, several medicinal wines prescribed in dispensatories are kept in the shops of apothecaries. Such are the astringent, antiscorbutic, febrifugal wines of the Peruvian bark, of wormwood, chalybeate wine, and others. In many cases, as in several chronical diseases, where tonic, cordial, fortifying and exciting remedies are indicated, physicians prefer the use of wine to water, as a vehicle for the infusion of purgative, aperitive, and other medicinal substances.

DCCXLI. WOAD. (z)

(z) Woad. Dr. Lewis in a note to his edition of Neuman's Chemical Works gives the following account of woad.

Woad, isatis, glastum, is a plant with long green leaves; the lower ones narrow at both ends; those which grow upon the stalk are broad at bottom like an arrow-head. On the tops come forth numerous yellow flowers, which are followed by little flat pods containing the seeds. It grows wild in some parts of France, and on the coasts of the Baltic Sea: the wild woad, and that which is cultivated for the use of dyers, appear to be the same species of plant. The preparation of woad for dying, as practised in France, is minutely described by Astruc, in his Memoirs for a Natural History of Languedoc. The plant puts forth at first five or six upright leaves, about a foot long and six inches broad: when these hang downwards, and turn yellow, they are fit for gathering: five crops are gathered in one year. The leaves are carried directly to a mill, much resembling the oil or tan-mills, and ground into a smooth paste. If this process was deferred for some time, they would putrefy, and send forth an insupportable stench. The paste is laid in heaps, pressed close and smooth, and the blackish crust, which forms on the outside, reunited if it happens to crack: if this was neglected, little worms would be produced in the cracks, and the woad would lose a part of its strength. After lying for fifteen days, the heaps are opened, the crust rubbed and mixed with the inside, the matter formed into oval balls, which are pressed close and solid in wooden moulds. These are dried upon hurdles: in the sun, they turn black on the outside; in a close place, yellowish, especially if the weather be rainy: the dealers in this commodity prefer the first, though it is said the workmen find no considerable difference betwixt the two. The good balls are distinguished by their being weighty, of a pretty agreeable smell, and when rubbed, of a violet colour within. For the use of the dyer, these balls require a further preparation: they are beat with wooden mallets, on a brick or stone floor, into a gross powder; which is heaped up in the middle of the room to the height of four feet, a space being left for passing round the sides. The powder, moistened with water, ferments, grows hot, and throws out a thick fetid fume. It is shovelled backwards and forwards, and moistened every day for twelve days; after which it is stirred less frequently, without watering, and at length made into a heap for the dyer.

The powder thus prepared gives only brownish tinctures, of different shades, to water, to rectified spirit of wine, to volatile alkaline spirits, and to fixed alkaline lixivia: rubbed on paper, it communicates a green stain. On diluting the powder with boiling water, and after standing some hours in a close vessel, adding about one twentieth part of its weight of lime newly slaked, digesting in a gentle warmth, and stirring the whole together every three or four hours, a new fermentation begins, a blue froth arises to the surface, and the liquor, though it appears itself of a reddish color, dyes woollen of a green, which, like the green from Indigo, changes in the air to a blue. This is one of the nicest processes in the art of dyeing, and does not well succeed in the way of a small experiment.

Astruc proposes the manufacturing of fresh woad leaves in Europe, after the same manner as the Indigo plant is manufactured in America;

DCCXLII. WOLFRAM. (*a*)

DCCXLIII. WOOL (PHILOSOPHIC). This is a name given by ancient chemical or alchemical authors to flowers of zinc. *See* FLOWERS *of* ZINC.

DCCXLIV. WORMWOOD. (*b*)

America; and thus preparing from it a blue fecula similar to indigo, which from his own experiments he has found to be practicable. Such a management would doubtless be accompanied with some advantages, though possibly, woad so prepared might lose those qualities which now render it, in a large business, preferable on some accounts to indigo, as occasioning greater dispatch when once the vat is ready, and giving out its color less hastily, so as to be better fitted for dying very light shades.

(*a*) WOLFRAM, *Spuma lupi*, is a very refractory mineral of a black or dusky color, crystallized in form of cubes, striæ, or other determinate shape, and consisting of shining plates. Its appearance is similar to the ore of tin, called tin-grains or crystals of tin: and it is frequently found in tin-mines. It is so hard that it can strike sparks from steel. When powdered, it is red. Wallerius considers it as an ore of iron mineralised by arsenic, which sometimes contains tin. According to Cronstedt, it is a kind of magnesia or manganese, containing a small portion of iron and of tin.

(*b*) WORMWOOD. The leaves of wormwood are intensely bitter, and have a strong smell, somewhat of the aromatic kind. They yield in distillation a considerable quantity of essential oil of a dark greenish color possessing the whole of their smell, the bitter matter remaining in the extract. *Neuman.*

Z.

DCCXLV. ZAFFRE, *or* SAFFRE. Zaffre is the residuum of cobalt, after the ſulphur, arſenic, and other volatile matters of this mineral have been expelled by calcination. It is therefore a kind of calx of cobalt, of a grey or reddiſh color. The uſe of cobalt is to produce a very fine blue color, when it is melted with fuſible and vitrifiable matters.

This blue color produced by the vitrification of zaffre proceeds from the earth or calx of a ſemi-metallic ſubſtance contained in cobalt, called by chemiſts, *regulus of cobalt*. This is proved by melting zaffre with a reducing flux, like any other roaſted ore; by which means the above-mentioned ſemi-metallic regulus of cobalt will be obtained. The ſcoria in this fuſion has alſo a blue color, which proceeds from a portion of the calx of this regulus that is not reduced, but is vitrified along with the ſcoria.

The calx therefore or metallic earth of the regulus of cobalt is the ſole cauſe of the blue color produced by zaffre. But as the quantity of regulus contained in cobalt is variable, therefore ſome zaffres furniſh more blue than others. The heterogeneous, fixed matters contained in cobalts, contribute, according to their quantity, not only to the greater or leſs intenſity of the blue color, but alſo to its luſtre and beauty. For which reaſon thoſe who manufacture zaffre from cobalt make frequent eſſays of the roaſted ore by mixing it with vitreous matters to diſcover the intenſity and beauty of the blue color.

Good cobalts calcined would form too deep a blue, and almoſt a black glaſs, if they were not previouſly mixed with a certain quantity of vitreous fritt. In the manufacture of zaffre, therefore, the calx of cobalt, the ſtrength of which has been previouſly determined by Eſſays, is mixed with ſuch a quantity of ſand, or of powdered flints and quartz, that with the addition of ſome ſaline flux, a deep blue glaſs may be formed.

The zaffre that is commonly ſold, and which comes from Saxony, is a mixture of calx of cobalt with ſome vitrifiable earth, as we have ſaid. It is of a grey color,

color, as all calxes of cobalt are before vitrification. Some zaffres are dearer than others, according to the intenſity of the color which they are capable of producing. Zaffre is employed in the manufacture of pottery and of porcelain, for painting the ſurface of the pieces of ware, upon which it is applied together with ſome ſaline flux, previouſly to the baking or glazing, that the ſame fire may alſo vitrify this coloring material.

The blue of zaffre is the moſt ſolid and fixed of all the colors that can be employed in vitrification. It ſuffers no change from the moſt violent fire. It is ſucceſsfully employed to give ſhades of blue to enamels, and to the cryſtal-glaſſes made in imitation of ſome opake and tranſparent precious ſtones, as the lapis lazuli, the turquois, the ſaphire, and others of this kind. *See the articles* AZURE, COBALT, INK (SYMPATHETIC), *and* SMALT.

DCCXLVI. ZEOLITES. (*c*)

DCCXLVII. ZINC. Zinc is a ſemi-metal, of a brilliant white color, approaching to blue. It is the leaſt brittle of the ſemi-metals; and when well furniſhed with phlogiſton, which may be effected by treating it with inflammable matters in a cloſe veſſel, it poſſeſſes a ſemi-ductility, by means of which it may be flattened into thin plates. (*d*).

This property, joined to its hardneſs, which is alſo conſiderable, renders it incapable of being pulveriſed like the other ſemi-metals; therefore, when it is required in a divided ſtate, it muſt be melted and granulated, or filed, like metals.

(*c*) ZEOLITES. This name is given by Mr. Cronſtedt to a ſtone deſcribed by him in the *Tranſactions of the Academy of Sciences at Stockholm for the year* 1756, the peculiar properties of which have induced that mineralogiſt to conſider it as forming a diſtinct order of earths, called *zeolites*. The properties of this ſtone or claſs of earths, are the following.

1. It is a little harder than the fluors, and calcareous ſpars. It may be ſcratched by ſteel, from which it does not elicit ſparks.

2. It may eaſily be melted by heat without addition, into a white frothy ſlag, which not without great difficulty can be rendered ſolid and tranſparent. Cryſtallized zeolites, when melted, boils, as borax does.

3. It may be diſſolved in the fire more eaſily by mineral alkali than by borax or by the fuſible ſalt of urine.

4. It does not effervеſce with the fuſible ſalt of urine, as calcareous ſtones do; nor with borax, as gypſeous ſtones do.

5. It diſſolves very ſlowly, and without effervеſcence, in acids, as in oil of vitriol, and ſpirit of nitre. When concentrated vitriolic acid is poured on powdered zeolites, a heat ariſes, and the powder is changed into a gelatinous maſs.

6. In the very moment of fuſion it gives a phoſphoric light.

Zeolites has been found only in an indurated ſtate. It is either, 1. conſiſting of particles of no determinate form; or, 2. *ſparry*; or, 3. *cryſtallized*.

The zeolites that conſiſts of particles of no determinate form, is either *pure*, and white; or it is *mixed with ſilver and iron*; which latter kind is of a blue color, and is commonly called lapis lazuli. *See* LAPIS LAZULI.

The *ſparry zeolites* reſembles calcareous ſpar, but is more brittle. This is of a light red, or orange color.

Cryſtallized zeolites. Groupes of cryſtals of zeolites are found in form of white or yellow balls conſiſting of many pyramids the apices of which unite in the center; or of white priſms with truncated angles; or of white capillary cryſtals.

Zeolites has in the fire nearly the ſame properties as boles have. See *Stockholm Tranſ.* for the year 1755, and *Cronſtedt's Mineralogy*, §. 108.

(*d*) Zinc when broken appears of many flat, ſhining plates, or facets, which are larger when ſlowly than when haſtily cooled. When

The specific gravity of zinc is nearly the same as that of regulus of antimony; that is to say, it loses in water about a seventh part of its weight. (*e*)

This semi-metal is not easily calcined or covered with rust by the action of the air and of water: in this respect it resembles tin. It is less fusible than tin and lead, as it does not melt till it is almost red-hot. When it only suffers the degree of heat necessary for its fusion, its surface is calcined and reduced to a grey calx, easily reducible, like those of tin and other fusible metallic substances. But when it is exposed to heat approaching to a white-heat, it flames; and during this inflammation it exhibits a very beautiful and striking appearance. The flame of zinc is infinitely more lively, more luminous, and more brilliant, than the flame of any other inflammable matter. It is of a dazzling white, and is so vivid as to be insupportable to the sight. This flame cannot be attributed to any sulphur which might be supposed to remain united with the zinc, for we shall see that this semi-metal cannot be united with sulphur; but merely to phlogiston, which in zinc is very combustible. This ardent deflagration is a most sensible proof of the presence of this principle in metallic substances.

The deflagration of zinc is so violent that the earth of this semi-metal although naturally very fixed, like that of almost all metallic substances, is raised in form of white smoke, which is condensed, and floats in the air like light flocks. These are called *flowers of zinc*, and *philosophical wool*. *See* FLOWERS *of* ZINC.

Zinc being the most combustible of all metals, detonates more violently than any other metal with nitre. From the whiteness and brilliancy of the flame produced by this detonation, it has been employed with very good effect as an ingredient in compositions for fireworks.

All acids are capable of dissolving zinc. Six parts of good vitriolic acid diluted with an equal weight of water can dissolve entirely, by help of gentle heat, one part of zinc. The neutral salt resulting from this solution is crystallizable; and is called *white vitriol*, or *vitriol of zinc*. See a description of the method in which this vitriol is made at Goslar, at the article SMELTING *of* ORES.

Zinc has a strong affinity with vitriolic acid. It appears to have a stronger than any other metallic substance: for by means of this semi-metal, the vitriols of copper and of iron may be decomposed. It separates these metals from the vitriolic acid, to which it unites and forms a white vitriol. But what is remarkable, is, that notwithstanding this great affinity of zinc with vitriolic acid, the vitriol of zinc is decomposed, and its acid separated by less heat than the martial vitriol, as Junker affirms in the first volume of his *Conspectus Chymiæ*. If this experiment succeeds, as probably it does, we must refer the cause of it to the particular states of the inflammable principle in zinc and in iron. All the properties of these two metallic substances shew that they abound in phlogiston, and therefore vitriolic acid unites with them preferably to any other. But, at the same time, this phlogiston is in these metals much

When heated, it is very brittle. Like tin, it makes a crackling noise when it is bent.

(*e*) According to Mulchenbroek's table of specific gravities, Indian zinc is to water as 7.2401 to 1: and zinc of Goslar is as 7.215 to 1.

unfolded.

unfolded and weakly combined, which is undoubtedly the caufe, that the neutral falts which they form with the vitriolic acid may be decompofed by the action of fire. For, the phlogifton of thefe metals adhering but flightly to their earth, may be more eafily combined with the vitriolic acid, and by converting this acid into volatile vitriolic, or fulphureous acid, may ftill more facilitate its feparation.

But as the inflammable principle of zinc is more abundant, and more flightly engaged than that of iron, zinc ought to unite with vitriolic acid preferably to iron, and the vitriol of zinc ought to be decompofed by fire more eafily than the vitriol of iron.

When white vitriol is diftilled by violent heat, nearly the fame phenomena happen as when martial vitriol is diftilled. Towards the end of the diftillation of white vitriol, a vitriolic acid arifes, dephlegmated, tho' very fulphureous. This acid added to common concentrated vitriolic acid produces as much heat as water would have done, if added to the fame concentrated acid.

Zinc may alfo be diffolved in the nitrous and marine acids. But this latter acid does not touch a black matter which feparates from the femi-metal during its folution. M. Hellot who has examined the phenomena of this folution as well as thofe of the folutions of this femi-metal in the vitriolic and nitrous acids, has afcertained that this black matter is not mercury, and that it cannot even be reduced into a metallic fubftance. (*f*)

Zinc may be allayed or mixed with all metallic fubftances excepting *bifmuth* (*g*). If thefe two metals be melted together, they will be found feparately at the bottom of the crucible, the zinc being the lighter lying above the bifmuth. The allay of zinc with iron is effected difficultly; but that with copper fucceeds well, and is much ufed, on account of a fingular property which zinc has of uniting with copper in a confiderable proportion; as, for inftance, one part of zinc to four or three parts of copper, without much diminution of the ductility of the copper. Zinc added to copper renders this metal lefs fubject to ruft, and gives to it a yellow color refembling that of gold. This copper fo allayed with zinc is called *brafs* or *latten*. *See* BRASS.

The color of brafs approaching to that of gold, has induced chemifts to fearch for the means of communicating to copper the true color of gold. And they have actually fucceeded in the compofitions or allays called *tombacs*, *fimilor*, *Pinchbeck*, and *Prince's metal*. Beccher had faid, that equal parts of copper and zinc mixed together gave a color to the touch-ftone like that of the gold from the Rhine. Stahl remarks that the proportion of zinc mentioned by Beccher is too great, but does not determine what this proportion ought to be. Since that time, the due proportion has been inveftigated, and feveral fine imitations of gold have been found. The Englifh were the firft who fucceeded, and they called their invention *Prince's metal*, or *Prince Rupert's metal*.

More perfect imitations of gold have been lately made by Lacroix and Leblanc; each of whom produced a metallic mixture, one of which excelled in

(*f*) Neuman fays, that this black matter was feparated during the folution of this femi-metal in vitriolic and in marine acids, and that two or three days afterwards it was re-diffolved.

(*g*) It cannot be allayed with the femi-metal called nickel.

ductility,

ductility, and the other in color. But these artists have not revealed their processes. M. Geoffroy has made with this view many experiments, the detail of which may be seen in the Memoirs of the Academy for the year 1725. It appears from these experiments, that the remark made by Stahl, that an equal quantity of zinc is too much, was very just, with regard to the ductility of the allay, but that equal quantities produced the finest color. We may nevertheless observe, that as copper requires a strong heat to keep it fused, and as zinc is very volatile, these two substances cannot be mixed without loss, both of the copper, some of which is calcined, and of the zinc, a part of which is burnt and dissipated in fumes. Hence it follows, that after the mixture is made, the proportion betwixt the two metals is not certain. After some experiments which I have seen, I can scarcely be persuaded that a fine-colored mixture can be obtained, and particularly of a deep enough yellow, if as much zinc as copper actually remained. *(b)*

We must also observe, that in order to have a fine-colored and ductile metallic mixture of this kind, it is necessary, according to Mr. Cramer, to use the purest zinc. The same author shews the means of purifying it, and of ascertaining its purity. This method is founded on the remarkable property which zinc has of being incapable of uniting with sulphur *(i)*. Therefore, to purify this semi-metal from the allay of other metals, it is necessary to throw upon it, when melted in a large crucible, suet and sulphur alternately, and the latter in larger quantities than the former. If the zinc is pure, the sulphur burns freely on its surface; but if it is allayed, the sulphur combines with the other metals, and forms with them a kind of scoria which must be taken off. This alternate projection of suet and sulphur upon zinc is continued till the sulphur be burnt on the surface of the melted zinc, without forming any scoria; the zinc thus purified, may be successfully employed for making of brass or metallic mixtures in imitation of gold.

The affinities of zinc are, according to Mr. Gellert's table, in the following order: Copper, iron, silver, gold, tin, and lead. This last is said to be only partly miscible with zinc. Sulphur might be so placed in this table, as to shew its incapacity of uniting with zinc.

The chief use of zinc is as an ingredient in the composition of brass. M. Malouin, who, in his Memoirs upon Zinc, has mentioned several properties of this semi-metal which he finds analogous to those of tin, relates in these Memoirs some experiments which he made with success, in order to substitute zinc for tin, in the operation upon iron plates, &c. called *tinning*. As all the properties

(b) One part of zinc is said to be capable of destroying the ductility of a hundred parts of gold. An allay of equal parts of zinc and gold is very hard, white, capable of receiving a fine polish, and not subject to rust or tarnish: hence it is proposed by Mr. Malouin as a good material for making specula of telescopes. Zinc gives hardness to tin, and is therefore added in some compositions for making pewter.

(i) Mr. Cramer says that zinc does not easily unite with sulphur, but that if it remains long in a moderate fire, and be covered over with sulphur at several times, and continually stirred with a poker, it will be at last changed into a very brittle, dark-colored substance. I suspect that the iron of the poker contributed to this union of zinc with sulphur, for I have never been able to unite sulphur with pure zinc, when I stirred them with a tobacco-pipe.

of

of this ſemi-metal are not yet diſcovered, it may perhaps be hereafter found applicable to other uſes. (*k*)

(*k*) Some authors, as Wallerius and ſtedt, ſay, that filings of zinc are attr magnets. I have not been able to this property.

Zinc unites more ſtrongly to aci any other metal, and even ſome earth Pott ſays, that it precipitates the earth from a ſolution of alum; and that zinc cannot be precipitated from aqua fortis by crabs-eyes. He alſo ſays, that it may be precipitated by volatile alkali, but that this precipitate is quickly re-diſſolved.

The ſame author ſays, that zinc, by being converted into flowers, acquires an additional weight, equal to $\frac{1}{10}$th part of the ſemi-metal employed.

Mr. Malouin relates, that zinc being melted ſix times, and the fuſion continued 15 hours each time, it became more and more hard, brittle, unfuſible, and uncalcinable. He ſays, that its color became grey after the ſecond fuſion, brown after the third, black after the fourth, blue like a ſlate after the fifth, and a clear violet-color after the ſixth.

Concerning the ores and eſſay of ores of zinc, *ſee* Ores *of* Zinc; and concerning the methods of extracting large quantities of this ſemi-metal from its ores, *ſee* Smelting *of* Ores, and Plate II. *Fig.* 15, and 22, with the explanations.

F I N I S.

CORRECTIONS AND ADDITIONS.

PAGE 2. *Notes, column second, line fourth.* Instead of, "them with a certain "quantity of water," read, "concentrated acids with a certain quantity "of water or of ice."

Page 3. *Notes, column first, line* 14. Instead of, "they," read, "most, if "not all of them, when much concentrated."

Ibid. col. 2, *line* 31. Instead of, "of solid acid in each neutral salt," read, "that "each neutral salt retains of the acid liquor employed in its preparation."

Page 4. *Notes, col.* 1, *line* 4. Instead of "shall," read, "should."

Ibid. line 8. Instead of, "Hence we may perceive, &c." *to the end of the sentence,* read, "But as a less quantity of acid was said to have been actually employed, "Mr. Homberg's alkali must have contained a less quantity of fixable air than "we have supposed. But as we do not know the precise quantity of that air, "nor the degree of dryness of his alkaline salt, we cannot from his experiments "ascertain the quantity of pure, dry, caustic alkali, contained in any of the "neutral salts produced; nor can we determine how much of the acid liquor "employed was retained in those neutral salts after they had crystallized."

Page 9. *Notes, col.* 2. *line* 8. Instead of, "but not volatile alkali," read, "but it does not render volatile alkali soluble in spirit of wine."

Page 33. *Note* (*b*), *line* 1. Instead of, "term," read, "name."

Ibid. ~~*Notes, col.*~~ 2, *line* 1. Instead of, "this," read, "his."

Page 34. *Notes, col.* 1, *line penult.* Instead of, "combined," read, "uncombined."

Page 35. *Notes, col.* 2. After the 28th line add, "Dr. Macbride shews, that the "air extricated from fermenting and putrefying substances is capable of com- "bining with caustic alkalis, and with quicklime, and of rendering these mild. "This air is therefore probably of the same kind as the air usually combined "with alkaline substances."

Page 37. *Notes, col.* 1. After the second line, add, "Concerning the fixable "air contained in *mineral waters*, and its power of *dissolving calcareous earth*, "and *iron* contained in these waters, *see the article* WATERS (MINERAL), *and* "*a Note subjoined.*"

Page 40. Add the following *note*, referring to the article ALKALESCENT. "This word signifies the tendency of bodies to become alkaline; and cannot "be properly applied to signify a slight degree of alkaline quality."

Page 49. *Notes, col.* 1, *line* 11. Instead of, "in ordinary distillations," read, "in the ordinary method of distilling wood, together probably with some of "its more fixed parts."

Page 55. *Notes*, *col.* 2, *line* 1. Instead of " this salt to," read, " the mineral to " the."

Page 62. *Notes*, *col.* 2, *line* 2. Instead of " by their different densities," read, " by fusion, according to their different densities, that is, the heavier metal " sinking below the lighter."

Ibid. line 25. Instead of " by their different densities," read, " by means of " their different densities."

Page 73. *Notes*, *col.* 1, *line* 9. Instead of " earth," read, " substance."

Ibid. col. 2, *line* 10. Instead of " The same," read, " An equal."

Page 75. *Notes*, *col.* 2, *line* 2. Dele " Hence."

Ibid. At the end of the note (*i*) add, " But as mercury has been found to rise " to a less height in barometrical tubes of iron than in those of glass, have " we not reason to believe that these metals possess a power of repelling each " other? *See the Hist. de l'Acad. Roy. de Sciences*, 1706."

Page 91, *line* 15. Instead of " flux," read, " resolvent."

Page 99. *Notes*, *col.* 2. *last line*. Instead of " cocoa," read, " coco."

Page 117. Instead of the paragraph beginning thus, " Some authors re- " commend, &c." read the following paragraph, as it is altered by the Author of the Dictionary.

" Several Chemists, amongst whom is Mr. Pott, have believed that the " solution of bismuth, which when well saturated, may be precipitated " by water, could not be precipitated by means of the marine acid, as those " of lead and silver may, and consequently that a corneous bismuth could not " be formed. But Mr. Rouelle, in his Memoir upon Salts, [*see Mem. de " l'Acad. des Sc.* 1754.] says, that after having precipitated from a well satu- " rated solution all the bismuth that he could by means of water, he obtained " a new precipitate by adding to the remaining liquor an equal quantity of " saturated solution of sea-salt, and by gradually mixing with these a quantity " of common water equal to four times the quantity of the two solutions. " This second precipitate is considered by Mr. Rouelle as a corneous bismuth.

" If this be the case, bismuth resembles lead in many of its properties, as " Mr. Geoffroy the Younger has shewn in the Memoirs of the Academy of " Sciences. Accordingly, some chemists have called bismuth, the *lead of the " semi-metals*."

Page 124. Instead of the paragraph beginning thus, " A chemist of Berlin " having, &c." read the following paragraph, as it is altered by the Author " of the Dictionary.

" Stahl relates in his *Three Hundred Experiments*, &c. No. 231, the manner " in which this blue matter was discovered. He says, that a manufacturer of " colors, called *Diesbach*, who usually prepared a lake of cochineal by mixing a " decoction of this substance with alum and green vitriol, and by precipitating " the mixture with a fixed alkali, being one day in want of fixed alkali, for " this purpose borrowed from *Dippel*, in whose laboratory he worked, some " salt of tartar, from which that chemist had several times distilled the animal " oil called *oil of Dippel*, and observed that the lake precipitated by means " of this alkali, instead of being red, was of a fine blue color. Dippel, to whom " Diesbach related this appearance, perceived that it must have been caused " by his alkali, and attempted to produce the same effects by giving the

same

" same quality to fixed alkali by an easier process. His attempts succeeded, " and from that time Prussian blue has been prepared."

Page 131. *Notes, col.* 2. *line penult.* Instead of " in," read, " of."

Page 138. *line* 20. Instead of " cacao, butter," read, " cacao-butter."

Ib. line 34. Dele " made."

Page 142, *line* 36. Instead of " that," read, " why."

Page 151, *line* 37. Instead of " ferruginous and sulphureous," read, " ferruginous, sulphureous."

Page 181. *Notes, col.* 2. *line* 4. Instead of, " after a red heat has been gradually applied," read, " after heat has been gradually applied till the crucibles become red."

Page 216. *Notes, col.* 1, *line* 12. dele " also."

Page 226. *Notes, col.* 1. *line* 22. Instead of the sentence beginning with, " If we mean by *element*, &c." read the following sentence: " But if we should " call every substance an *element* which we cannot analyse, then certainly many " other substances besides the above-mentioned four might be enumerated " as elements."

Page 253. Add the following *note*, referring to the *sixth line.*

" The method employed by Mr. Beaumé for obtaining a marine ether, " namely, by uniting the vapors of spirit of wine with those of marine acid, " has been successfully attempted by *Mr. Woulfe.* This ingenious chemist " condensed the united vapors of the spirit of wine, and of the marine acid, by " making them pass from the receiver through a tube into spirit of wine con" tained in a bottle, and by making those which were not thus condensed pass " through another tube into more spirit of wine contained in another bottle. " By distilling and cohobating with slaked lime the liquors in the receiver, and " in the two above-mentioned bottles, he obtained a very subtle and pene" trating ether. *See a description of the apparatus employed by Mr. Woulfe, and* " *many curious particulars concerning distillation, in the Philosophical Trans-* " *actions,* ~~Vol.~~ LVII."

Page 254. Add the following *note*, referring to the *seventeenth line.*

" *Mr. Woulfe* describes an apparatus by which nitrous ether may be expediti" ously obtained by distillation, with the heat only occasioned by mixing together " the nitrous acid and the spirit of wine. This distillation is performed in a " matrass with a high neck, to which is fitted a head, with a spout, commu" nicating with the receiver by means of a long tube. Those vapors which are " not condensed in this receiver are conveyed from thence through a bent " tube into spirit of wine contained in a bottle; and if any vapors pass uncon" densed through this spirit of wine, they are conveyed, through another bent " tube, into more spirit of wine contained in another bottle. The liquor " collected in the receiver, being slowly rectified with slaked lime, furnishes " very fine ether. The spirit of wine in which the vapors were condensed " contains so much ether, that this fluid may be separated from the spirit by " adding water. This spirit of wine is, by the operation, converted into very " good dulcified spirit of nitre. *See the Phil. Trans. Vol.* LVII.

Page 276. *Notes, col.* 1. *line* 39. Instead of, " when the flame has a con" siderable diameter, as of a foot or eighteen inches, and," read, " when a

" vapor

" vapor of a confiderable diameter, as of a foot or eighteen inches, is kindled, " and the combuftion"

Page 278. *Notes, col.* 2. *line* 4. Inftead of the fentence beginning, " They " are alfo convertible, &c." read, " By means of fixed alkali they may be fufed " and vitrified: and when the quantity of fixed alkali is much greater than " that of the flints, the melted mafs deliquiates by expofure to a moift air, and " becomes the liquor called *liquor of flints*, from which an earth may be preci- " pitated, by adding an acid. This earth, which muft have been originally " the earth of the flints or fand employed, is now rendered foluble in acids, " and, as Mr. Pott fays, is *calcareous*, or, as Mr. Beaumé affirms, is *argilla-* " *ceous.*"

Page 294. Dele *Note (m).*

Page 301. *Notes, col.* 1. *line* 5. Inftead of, " contain nitre, fal ammoniac, " or common falt, alum, or fome vitriolic falt," read, " contain nitre, alum, " or other vitriolic falt, and fometimes fal ammoniac or common falt."

The fame page, Notes, col 1. *line penult.* Inftead of the three fucceffive fentences, the firft of which begins thus, " Accordingly, in all the receipts, " &c." and the laft of which fentences ends thus, " quickly plunges it in water," read the following: " This effect may be produced either by applying to the " metal an aqua fortis, by which any remaining mercury, or allay of copper, " or of other metals, that might difcolor the gold, might be diffolved; or by " an aqua regia, which alfo would cleanfe its furface, but, at the fame time, might " diffolve the gold itfelf, if applied a time fufficiently long. Now, in all the " receipts which I have feen for this faline compound, I have always obferved " nitre and alum, or fome vitriol, together with other matters. From thefe " ingredients, by expofure to heat, an aqua fortis is evidently formed, the acid " of the alum or other vitriol difengaging the acid of the nitre. In feveral of " thefe receipts I have feen added to the above-mentioned falts fome fal ammo- " niac or common falt. By this addition, an aqua regia is formed, which may, " as we have faid, alfo cleanfe the furface of the gold; but, as it may diffolve " part of the gold itfelf, even in the very fhort time during which it is applied, " the former compound, from which the nitrous acid only is difengaged, feems " to be preferable, and is now generally employed."

Page 336. *Notes, col.* 2. *line* 13. Inftead of, " that it deliquiates," read, " that glafs-gall deliquiates."

Page 310. *Notes, col.* 1, *line* 5. Inftead of, " but thofe perfons," read, " but this action of Mofes is evidently related, and ought to be confidered, " as miraculous, and therefore not explicable by natural means. As to thofe " perfons"

Ib. col. 2, *line* 1. Inftead of, " will," read, " they will."

Page 312, *line* 20. Inftead of, " and fo fixed," read, " and will become fo " fixed."

Page 314. *Notes, col.* 2, *line* 3. After " fufed," add a *comma.*

Page 478. *Notes, col.* 1, *line* 6*th from the bottom.* Inftead of " coeval," read, " coeval, or nearly coeval."

Page 316, *line* 38. Inftead of, " behind," read, backwards."

Page 324, *line* 15. Add the following *Note.* " This propofal is of a much " older date than the Memoir of M. de la Condamine."

Page

Page 361, *line* 20. Inſtead of, " citing," read, " exciting."

Page 409, *line* 23. Inſtead of, " method of friction," read, " method by " friction."

Page 425, *line* 15. Inſtead of, " By water," read, " With water."

Page 429. *Notes, col.* 2, *line laſt*: Inſtead of, " copper, iron," read, " iron, " copper."

Page 476. *Notes, col.* 1, *line* 4. Dele " up."

Page 479. *Notes, col.* 1, *line* 3. After " in a fluid ſtate," add, " and diſſolved " in water;"

Page 504. *Notes, col.* 2, *line 9th from the bottom*. Dele " alſo."

Page 552. *Notes, col.* 1, *line* 1. Inſtead of, " The petuntſe is improperly " ranked amongſt the claſs of earths called vitrifiable, becauſe, &c." read, " The petuntſe is ranked amongſt the earths called vitrifiable, improperly, as " I think, becauſe, &c."

Same page, col. 2; *line 3d from the bottom*. Inſtead of, " analiſed," read, " analyſed."

Page 555. *Notes, col.* 1, *line* 14. Inſtead of, " all of which are fuſible," read, " which are ſingly or jointly fuſible."

Page 591. *Notes, col.* 1, *line* 10. Inſtead of, " inexhauſted," read, " ex- " hauſted."

Same page, Notes, col. 1, *line* 24. Add, " But no inferences ought to be " drawn from experiments, which appear, from the author's own account, to " have been inaccurate, and not repeated."

Page 607. *Notes, col.* 1, *line* 4. Inſtead of, " or," read, " as."

Page 608. *Notes, col.* 1, *line* 9. Inſtead of, " unites ſo rapidly as to occaſion," read, " unites rapidly, and occaſions."

Page 742. *Notes, col.* 1, *line* 4. Inſtead of, " volatile, vitriolic," read, " vo- " latile vitriolic."

Page 815. *Notes, col.* 1, *line* 11. Inſtead of, " crown-glaſs," read, " flint- " glaſs;" and *line* 12, inſtead of, " flint-glaſs," read, " crown-glaſs."

EXPLANATION

OF THE

PLATES.

PLATE I.

FIG. I. A RETORT.
A, Its belly or bowl.
B, Its neck.
FIG. 2. Retorts of this form are called *English Retorts.*
FIG. 3. A GLASS ALEMBIC.
A, The cucurbit.
B, The head.
C, The gutter within the head.
D, The beak.
FIG. 4. A LONG-NECKED GLASS ALEMBIC.
A, The body of the matrass.
B, The neck of the matrass.
C, The head of the alembic.
FIG. 5. A GLASS ALEMBIC *consisting of one Piece.*
A, The cucurbit.
B, The head.
C, The aperture in the head.
D, Its stopple.
E, The mouth of the cucurbit.
FIG. 6. A PELICAN.
A, The cucurbit.
B, The head.
C, The aperture in the head with its stopple.
D, The two curved spouts.
FIG. 7. A ROW *of* ALUDELS.

FIG 8. A COPPER ALEMBIC.

A, The body or cucurbit.
B, The neck.
C, The head.
D, The beak, nose, or spout.
E, The refrigeratory or cooler.
F, Its cock.
G, The receiver.

FIG. 9. A MUFFLE.

FIG. 10. *A perpendicular section of a* CUPPEL *or* TEST. The curve line represents the bottom of the cavity that contains the metal. The plan or any horizontal section of a cuppel is a circle.

FIG. 11. AN INGOT-MOULD, into the cavities of which melted metals are poured.

FIG. 12. AN APPARATUS *for* DISTILLING, by which the vapors that usually escape in the ordinary method of distillation, are condensed by passing into water or some other fluid. This apparatus was invented and described by Mr. Peter Woulfe. *See the Phil. Trans. Vol.* LVII.

A, a retort. Instead of this retort, in the distillation of some substances, may be substituted an iron pot with a stone-ware head, the neck of which is to be inserted into the receiver, as in the present Figure.

B, a receiver, with a neck, into which the neck of the retort is to be inserted; and a spout at its bottom, through which the distilled liquor passes into the bottle C; and an opening in the side at D, into which one end of a tube bent at right angles is inserted. The other end of this tube passes into a vessel H, open at both ends, the lower opening of which is closed with a glass stopple. Through the upper mouth of the vessel H, one end of another tube I, bent twice at right angles, passes, while the other end of this tube is inserted into a bottle F, and immersed in the water or other fluid contained in that bottle. The crooked tubes are fitted into the mouth of the vessel H by means of a cork, in which are two semicircular notches, through which the tubes pass, and by lute.

The tube which passes into the bottle F is fitted into the mouth of this bottle by means of a cork, in which is a semi-circular notch. This mouth of the bottle F is not closed with lute.

The vapor that is raised from the substance exposed to heat in the retort passes into the receiver B, where part of it is condensed, and flows into the bottle C, while the rest of it passes through the tube at D, into the vessel H. From this vessel, the vapor that still remains uncondensed passes through the crooked tube I, into the water contained in the bottle F, by which it is all condensed excepting some elastic air, which is extricated in almost all distillations. This elastic air rises through the water, and escapes at the semi-circular notch of the cork in the mouth of the vessel, which is therefore not accurately closed by lute.

In most distillations a quantity of air is absorbed at different times during the process: and in this case the external air will press on the liquor in the bottle F, and force it through the tube I into the vessel H, from which it may be taken by opening the stopple L.

The uſe of the veſſel H is to receive the liquor that may be thus raiſed from the bottle F, and to prevent it from paſſing into the receiver B, and from thence into the bottle C, where it might ſpoil the diſtilled liquor.

Mr. Woulfe, in the above-mentioned Philoſophical Tranſaction, relates ſeveral experiments made with this apparatus, from which the utility of this method of condenſing vapors by making them paſs into water, or ſome other fluid ſuited to the nature of the liquor diſtilled, appears.

Thus, by diſtilling twelve pounds of ſal ammoniac with quicklime and two gallons of water, he obtained eight pounds and a quarter of volatile alkaline ſpirit ſufficiently ſtrong to make eau de luce, which were collected in the bottle joined to the receiver; and upon adding two other gallons of water, he obtained ſeven pounds of weak volatile alkaline ſpirit. The water contained in the bottle F, which was ſix quarts, received an encreaſe of $2\frac{1}{2}$ lb. in weight from the vapor condenſed in it; and from experiments made to compare the ſtrength of the alkali thus condenſed by the water with that of the ſtrongeſt alkaline liquor firſt obtained, and which we have ſaid was fit for making eau de luce, it was found, that the ſtrength of the former was to that of the latter as 140 to 76: hence the quantity ſaved by this apparatus was nearly equal to five pounds of volatile alkali ſufficiently ſtrong for making eau de luce. Mr. Woulfe obſerved a ſingular difference betwixt the alkaline liquor collected in the bottle joined to the receiver, and that which was condenſed in the water in the bottle F, namely, that a conſiderable heat was excited by mixing the latter alkaline ſpirit, but not the former, with vitriolic acid.

Another experiment is related, of the diſtillation of twelve pounds averdupoiſe of common ſalt with an equal quantity of oil of vitriol diluted with 7 lb. of water. In this operation 9 lb. $5\frac{1}{2}$oz of ſpirit of ſalt were collected in the bottle C, and 6 lb. $12\frac{1}{2}$oz. of the ſame ſpirit were condenſed in ſix quarts of water in the bottle F. The reſiduum weighed 18 lb. 6 oz. Hence in this operation there was a loſs of eight ounces, or $\frac{1}{70}$th part of the whole, moſt of which probably was elaſtic air. The ſtrength of the acid condenſed in the water was found, by experiment, to be to the ſtrength of the acid collected in the bottle C, as 200 is to 109. Theſe vapors, condenſed in water, were found to be more concentrated when the diſtillation was conducted ſlowly than when it was haſtened. It appeared alſo, that the moſt concentrated portion of the acid of ſea-ſalt is the moſt volatile, and that its ſtrength was to that of vitriolic acid (the ſpecific gravity of which was to that of water as 24 to 13), as $44\frac{1}{4}$ to 31. Experiments alſo ſhewed, that this vapor of ſpirit of ſalt condenſed in water contained no vitriolic acid, although the ſpirit collected in the bottle C did contain ſome of that acid.

The ſame ingenious chemiſt formed a *marine ether* by applying the vapor of rectified ſpirit of wine to this very concentrated vapor of marine acid, and by condenſing the united vapors in ſpirit of wine. This he effected by a well contrived apparatus. The necks of two retorts, one of which contained the ſpirit of wine, and the other the ſea-ſalt and vitriolic acid, from which the marine acid was to be diſtilled, opened into one receiver, where the vapors met: from this receiver the vapors paſſed through a tube into ſpirit of wine contained in a bottle; and thoſe which were not there condenſed paſſed through another tube into ſpirit of wine contained in a ſecond bottle. By a further

 diſtillation

diſtillation and cohobation, with ſlaked lime, of the ſeveral liquors collected in the receiver and in the ſpirit of wine in which the vapors were condenſed, a very ſubtle penetrating ether was produced. Mr. Beaumé had tried to procure a marine ether by uniting the vapors of the marine acid, and of ſpirit of wine; but he failed, becauſe he did not uſe an effectual method of condenſing the vapors.

Mr. Woulfe did not find that much advantage was gained by this method of condenſing vapors in water, in the diſtillation of the nitrous acid from nitre mixed with vitriolic acid, excepting that thus the noxious fumes are prevented from hurting the operators.

He thinks his propoſed method of condenſation may be applicable to the diſtillation of vitriolic acid, the ſulphureous fumes of which are difficultly condenſible; to the rectification of phoſphorus, the vapor of both which ſubſtances ought to be condenſed by means of water; to the rectification or diſtillation of vitriolic ether, the vapors of which ought to be condenſed in ſpirit of wine; and, laſtly, to many other diſtillations.

PLATE II.

Fig 1. *An* Essay *or* Cupelling Furnace. This figure and the following deſcription of this furnace are copied from *Cramer's Art of Aſſaying*. *See Dr. Mortimer's Engliſh Edition, p.* 75.

" The aſſaying furnace is made in the following manner: Make with iron plates a hollow quadrangular priſm, eleven inches broad and nine inches high (*a a*, *b b*), ending at top in a hollow quadrangular pyramid (*b b*, *c c*), ſeven inches high, terminating in an aperture at top ſeven inches ſquare. This priſm muſt be cloſed at bottom with another iron plate, which ſerves as a baſis or bottom to it (*a a*). 2. Near the bottom make a door (*e*) three inches high, and five inches broad, that leads to the aſh-hole. 3. Above this door, and at the height of ſix inches from the baſis, make another door (*f*), of the figure of a ſegment of a circle, four inches broad at its baſis, and three inches and a half high in the middle. 4. Then faſten three iron plates on the forepart of this furnace; let the firſt of them (*g g*), eleven inches long and half an inch high, be faſtened, ſo that its lower edge ſhall reſt againſt the bottom of the furnace, with three or four rivets, and in ſuch a manner, that there may be between the upper edge of the ſaid plate and the ſide of the furnace a groove ſo wide, as that the ſliders of the lower door (*k k*) may be put into it, and freely move backwards and forwards therein: theſe muſt be made of a thicker iron-plate. The ſecond iron-plate (*h h*), eleven inches long, three inches high, and perfectly parallel to the foregoing plate, muſt be faſtened in the ſpace between the two doors, in ſuch manner, that both the upper and the lower edge of it may form

form a hollow groove with the side of the furnace. One of these grooves, which is turned downwards, serves to receive the upper edges of the sliders that shut the lower door (No. 2.) The other, that turns upwards, is to receive the inferior edges of the sliders of the small door above (No 3). The third plate (*i i*), which is like the first, must be rivetted close above the upper door, in such manner, that it may form a groove turning downwards, and contiguous to the upper edge of the upper door (No. 3.). 5. In order to shut both doors (No. 2. and 3.), you must adapt to each of them two sliders made of iron-plates, that may move within the above-mentioned grooves (*k k*, *l l*); but the two sliders belonging to the upper door (No. 3.) must have each a hole near the top; that is, one a small hole one fifth part of an inch broad, and one inch and a half long (*m*); and the other a semi-circular aperture, one inch high and two inches broad (*n*). Let, besides, each slider have a handle, that they may be laid hold of when they are to be moved. 6. Moreover, let five round holes, one inch broad, be bored in the furnace, two of which must be made in the fore-part of the furnace (*o o*), two others in the back-part, all at the height of five inches from the bottom, but three inches and a half distant from each side of the furnace; and, finally, a fifth hole (*p*), at the height of one inch above the upper edge of the upper door (*f*). 7. In short, let the inside of the furnace be armed wirh iron-hooks, jetting out half an inch, and about three inches distant from each other, to fasten the lute with which the furnace is to be covered over within. 8. Let then an iron, moveable, hollow, quadrangular pyramid (*q*), three inches high, be adapted to the upper aperture (*d*) of the furnace, at the basis seven inches broad, ending upwards in a hollow tube (*r*), three inches in diameter, two inches high, almost cylindrical, though somewhat convergent at top. This prominent tube serves to support a funnel or flue, which is almost cylindrical, hollow, made of iron-plates, and two foot high, and which, when a very strong fire is required, is put perpendicularly upon the shorter tube, in such manner, that it enters close into it, one inch and a half, or two inches deep, and may again be taken off at pleasure, when there is no need of so strong a fire. But this pyramidal cover (*q*) must besides have two handles (*s s*) adapted to it, that it may be laid hold of, and thus be taken away or put on again: and that this, being put on the aperture (*d*) of the furnace, may not be easily thrown down, let an iron plate be rivetted to the right and left upper edge of the furnace (*c c*), and be turned down towards the inside, so as to make a furrow open before and behind, into which the lateral edges of the cover may enter and be fastened, and at pleasure be moved backwards and forwards, whenever it must be put on, or moved. 9. Let a square ledge, made of a thick iron-plate, be fastened at top of the upper edge of the lower door (*e*); this is designed to support the grate and the lute: but it must be made of two pieces, that it may be easily introduced into the cavity of the furnace. Thus you will have an assay-oven, which must afterwards be covered over on the inside with lute. This you are to do as follows:

"That the fire may be better confined, and that the iron may not be destroyed by growing red-hot, the whole inside of the furnace must be covered over with lute, one finger or one finger and a half thick. The lute fit for this is made of a mass of clay mixed with sand, and moistened with three or four times as

much

much of ox-blood diluted with water *. But before you cover the inside of your furnace with this lute, you must first put within the furnace small iron bars, equal in length to the diameter of the oven, quadrangular, prismatical, half an inch thick, having their extremities supported by a square iron ledge, and three-fourths of an inch distant from each other; and you must fasten them so, that their flat sides may be oblique with regard to the transverse section of the furnace, and that the two opposite angles may look one upwards and the other downwards; the bars must not be laid flat, but edge-ways, by which situation you hinder the ashes of the fuel of the fire from being detained too long between the interstices of the said iron-bars, and from making an obstruction that would oppose the free draught of the air. The furnace being then covered over with lute, and dried up by a gentle heat, is at last fit for docimastical operations, and especially for such as must be performed in the assay-oven.

If then an operation is to be made in the furnace hitherto described, you must let through the four lower holes above described, of the furnace (*o o*) placed before and behind, and directly opposite to each other, two iron-bars one inch thick, and long enough that their extremities on every side may jut out of the holes a small matter. These serve to support the muffle and its bottom (*See* PLATE I. FIG. 9.). You then introduce the muffle through the upper aperture of the furnace (*d*), and place it upon the above-described iron-bars, in such manner, that the open fore-side of it be contiguous to the inward border of the upper door (*f*). The fuel of the fire is introduced through the top of the furnace (*d*); the cover of which, on this account, must be moveable and not very heavy (*q*). The best fuel for the fire is charcoal made of the hardest wood, especially of beech, broken into small pieces of the bigness of an inch, wherewith the muffle must be covered over some inches high. We then reject larger bits of coals, because they cannot fall through the narrow interstices, between the sides of the muffle and those of the furnace, and cannot, of course sufficiently surround the circumference of the muffle. Whence it happens, that there are on every side places void of fuel, and the fire is either not strong

* The best lute, and easiest to be had at London, is a sort of clay called Windsor loam, which must be mixt pretty stiff, and pressed into the inside of the furnace, first wetted with water; and when the clay begins to dry, it must be beat down close to the sides with a wooden mallet; then the unevenness and cracks filled up with fresh clay somewhat moister, so as to be made smooth and even with a trowel, and then left to dry gently; and if any cracks happen, they must again be filled up. *Note of Dr. Mortimer.*

Stourbridge clay, tobacco-pipe clay, or any other pure clay that is not fusible by fire, may be used for this purpose. But as fresh clay shrinks and cracks very much in drying, it ought to be mixed with an equal quantity or more of coarse white sand, or of burnt clay grossly powdered. Thus one part of Stourbridge clay, one part of coarse white sand, and one part of Stourbridge bricks grossly powdered, being well mixed together, make a good lute for lining the inner surfaces of furnaces. To prevent the iron plates of the furnaces more effectually from calcination, their inner surfaces ought to be covered with a coating of charcoal-powder formed into a mass or paste, with as much fresh clay and water as are sufficient for that purpose; and when this coating is dry, the above-mentioned lute may be applied. During the drying the lute ought to be daily beat with a mallet, that the spaces left by the shrinking of the clay may be closed, and the lute be rendered more compact.

enough

enough or unequal. But if, on the contrary, you uſe coals too ſmall, then a great part fall immediately through the interſtices of the grate into the aſh-hole; and the tendereſt particles of them turn too ſoon into *aſhes*, and by increaſing the heap of aſhes, obſtruct the free draught of the air, which is here greatly requiſite.

" A perfect management of the fire is moſt commonly neceſſary in the performing of operations in this furnace; therefore the reader muſt give attention to what follows: If the door of the aſh-hole (*e*) is quite open; and the ſliders of the upper door (*f*) drawn towards each other, ſo as touch one another in the middle of the door; and if, beſides, the cover (*q*), and the funnel adapted to its tube (*r*), is upon the top (*q*) of the furnace, the fire will be then in the higheſt degree poſſible; though, in the mean time, it is hardly ever neceſſary to put the funnel on, except in a very cold ſeaſon: but if, after having diſpoſed the furnace in the manner juſt deſcribed, you put red burning coals into the open upper door (*f*) of it, the fire is ſtill more increaſed thereby: however, this artifice is never, or very ſeldom, neceſſary. When you ſhut the upper door with only that ſlider that has a narrow oblong hole in it (*m*), then the heat becomes a little leſs; but it diminiſhes ſtill more when you ſhut the door with the other ſlider that has in it the ſemi-circular hole (*n*), which is larger than that of the firſt ſlider: nay, the heat again is leſs when you take away the funnel put at top of the cover: finally, the door of the aſh-hole being either in part or totally ſhut, the heat is ſtill diminiſhed, becauſe the draught of the air, ſo neceſſary to excite the fire, is thereby hindered: but if, beſides all theſe, you likewiſe open the upper door quite, then the cold air, ruſhing into the muffle, cools the bodies put under it, that are to be changed, to a degree never required in any operation, and ſuch as will entirely hinder the boiling of lead. If, during the operation, the fire begins to decay, or to grow unequal, it is a ſign that there are places void of coals between the ſides of the furnace and thoſe of the muffle; therefore, in this caſe, you muſt ſtir your coals on every ſide with an iron-rod, which is to be introduced through the upper hole (*p*) of the furnace, that they may fall together, and thus act in a proper manner and equally.

" However, you are to obſerve concerning the regimen of the fire juſt deſcribed, that though the *apparatus* is made with all the exactneſs mentioned, nevertheleſs the effect does not always anſwer it. The cauſe of which difference has moſt commonly its origin in the various diſpoſitions of the air; for as every fire is more excited by coals in proportion as the air, more condenſed, and more quickly agitated, ſtrikes them more violently (which the effect of bellows plainly ſhews); it thence appears, that in warm and wet weathers, when the atmoſphere is light, the fire muſt be leſs efficacious in furnaces; that likewiſe, when ſeveral furnaces, ſituated near each other, are burning at the ſame time, the fire is in part ſuffocated; becauſe the ambient air is thereby rendered more rare and lighter. The ſame effect is produced by the ſun, eſpecially in ſummer-time, when it ſhines upon the place where the furnace is ſituated. The atmoſphere, on the contrary, being heavier in cold dry weather, excites a very great fire.

" The heat of the fire acts the ſtronger upon the bodies to be changed, as the muffle put in the furnace is leſs; as the ſaid muffle has more and larger ſegments cut out of it; as the ſides of this muffle are thinner; in ſhort, as there are more

veſſels

veſſels placed in the hinder part of the muffle; and on the contrary. In this caſe, when many of the conditions requiſite for the exciting of fire are wanting, then indeed the artificer, with all his ſkill, will hardly be able to excite the fire to a ſufficient degree, in order to perform operations well, in common aſſay-ovens, even though he uſes bellows, and puts coals into the upper door of the furnace. For this reaſon, I have put the grate almoſt three inches below the muffle, leſt the air, ruſhing through the aſh-hole, ſhould cool the bottom of the muffle, which happens in common aſſay-ovens; and again, that the ſmaller coals, almoſt already conſumed, and the aſhes, may more eaſily fall through the interſtices of the grate, and the larger coals ſtill fit to keep up the fire be retained. Finally, I have added the above-mentioned funnel, that the blowing of the fire being, by means of it, increaſed as much as poſſible, this might at laſt be carried to the requiſite degree; for the fire may always be diminiſhed, but not always be increaſed at pleaſure, without the aſſiſtance of a proper *apparatus*."

FIG 2. This figure repreſents a furnace called an ATHANOR. *See* ATHANOR. This figure and the following deſcription are copied from *Cramer's Art of Aſſaying*. "This furnace is uſed for the diſtillation of acid ſpirits, for calcinations, cementations, &c. As theſe operations require a long and conſtant fire, an athanor is uſeful, becauſe it can contain as much freſh fuel as will keep up the fire for many hours together, and admits of a different, an accurate, and moſt conſtant regimen of the fire.

"Let then, 1ſt, a ſmall ſquare hollow tower *(a a a a)* be conſtructed of ſuch *ſtones*, [or of bricks made of *Stourbridge clay*, or *Windſor loam*,] as may reſiſt the fire; let the ſides of it be ſix inches thick, and forming a ſquare cavity within, of ten inches on each ſide *(b b b b)*. The height of it is determined according as it is to keep up the fire long, without any addition of new fuel: five or ſix feet are moſt commonly ſufficient. 2. At the bottom of this tower make an opening (*c*), ſix inches broad, and as many inches high; hang to it an iron door, being on every ſide one inch broader than the opening, and ſuch as may ſhut it very cloſe: for which purpoſe the external edge of this opening muſt be excavated all round in ſuch manner, that it may form a groove one inch broad, into which the edges of the door may be received. 3. At the diſtance of ten inches from the bottom of the tower, put a grate *(d)*, made of priſmatical, quadrangular iron-bars, one inch thick, and three quarters of an inch diſtant from each other: let alſo each of theſe iron bars be ſo ſituated with regard of the tower, that the two oppoſite acute edges of each may look perpendicularly, one downward, the other upwards, that, by this means, the aſhes may eaſily fall into the aſh-hole. 4. Make above this grate an opening circular at top *(e)*, ſix inches high, ſeven inches broad, that may, as well as the aſh-hole. (No. 2,) be open and ſhut with an iron door. 5. Adapt to the top of the tower an iron cover *(f)*, exceeding the aperture of the tower all around two inches, and having a handle, wherewith it may be eaſily taken away, and put on again. Thus you are to make the furnace called in Latin, *furnus primarius*. 6. Then cut out in any ſide of the tower, for inſtance, in the left, an oblong ſquare aperture, going up obliquely towards the outſide *(g g)*, four inches and a half high, ten inches broad, having its inward inferior

inferior edge, one inch and a half, or two inches above the grate (*d*); that by the intervening of this hole, the cavity of this tower may communicate with another immediately to be described. 7. Nearly over-againſt the ſame ſide of the tower, make a cavity with ſtones, whoſe inferior part muſt be a hollow priſm, (*h*, *h*, *h*, *h*,) ſix inches high, twelve inches broad, ending at top in a ſemi-cylindrical arch (*i*, *i*,) deſcribed by a *radius* of ſix inches; that by this means, the height of the whole cavity may be twelve inches in the middle. Let this anterior cavity be totally open, though, when requiſite, it is to be ſhut very cloſe with an iron plate (*k*, *k*,) whoſe inward ſurface is to be conſtructed in the ſame manner as is preſcribed for the ſliding door of the melting furnace, (Fig. 4,) and then luted two inches thick within. Moreover, let there be in the middle of this plate, a round hole, four or five inches in diameter, and let the circumference of this hole have an iron cylindrical border made to it, and prominent within; that by means of it, the lining of lute within may be ſupported, and kept from falling down eaſily. Let a notch one inch broad, and two inches deep, be made in the outward circuit of the aperture of this cavity, to receive the extremity of the plate that ſhuts the aperture. The hole of this plate, either is ſhut with a ſtopple, or ſerves to paſs the neck of the retort through. This plate likewiſe is faſtened with two bolts (*n*, *n*,), to be put horizontally with iron hooks (*o*, *o*, *o*, *o*,) driven into the wall near the edge of the aperture, ſo that one bolt may faſten the upper part of the plate, and the other the lower. 8. It is moreover proper, that the ſquare aperture (*g*, *g*,) through which the fire enters from the tower into the cavity hitherto deſcribed (No. 7.), may be ſhut and opened at pleaſure with an iron ſlider: for if this is not done, an exceſſive fire, employed ſometimes by an unexperienced hand, cannot be ſo eaſily checked. For this purpoſe, let a ſlit half an inch broad, and eleven inches long, be left in the wall that conſtitutes the upper part of the cavity (No. 7,), and is contiguous to the tower; ſo that it may exceed the length of the ſquare aperture (*g*, *g*,) a ſmall matter on every ſide, and reach before and behind into the ſmall groove, going down along the perpendicular ſides of the ſaid aperture, (*g*, *g*,) and retain the iron-ſlider to be put into it to keep it ſteady. However, let this iron-ſlider be ſix lines thick, eleven inches broad, and five inches high; and let a couple of ſmall iron-chains (*p*, *p*,) be faſtened on each ſide of its upper edge, wherewith the ſlider may be lifted up and let down again. Therefore, let a couple of ſtrong iron-nails be drove into the contiguous wall of the tower, perpendicularly over thoſe places in which the ſaid ſmall chains are faſtened to the iron-ſlider; that any of the links of the chains may be ſuſpended on them at pleaſure. Moreover, let the upper edge of the ſlit above deſcribed be entirely ſhut up with ſtones and cement, leaving only two ſmall holes through which the ſmall chains may be paſſed. On the left of this cavity (No. 7.), and at the diſtance of eight inches from the bottom of it, let a ſquare (*q*, *q*, *q*, *q*,) chimney or funnel be erected with *bricks*, three inches and a half in the clear, four foot high, and a ſmall matter convergent upwards, ſo that the diameter of it at top may be three inches. This funnel muſt be contrived to be ſhut cloſely with an iron-ſlider, having a handle to it (*r*, *r*,) which ſlider muſt move freely between a double iron ſquare frame faſtened in the walls of the funnel, at ſuch a height from the

hearth as ſhall ſeem convenient to any artificer. 10. Below this chimney, let a ſquare aperture be made, like the foregoing (No. 6, *g*, *g*,), leading obliquely up to the bottom of another cylindrical cavity (*u*, *u*, *u*, *u*,) which is eight inches deep, deſcribed by a *radius* of ſix inches, open at top, and then, converging inwardly into a border one inch thick, and ſix lines broad, deſigned to ſupport an iron-pot. Likewiſe, cut in the anterior wall of this cavity, and at the upper part of its mouth, a ſegment two inches and a half deep, five inches broad, and ſtooping forward (*v*, *v*,) to receive the neck of the retort. 11. To this cavity (No. 10.) belongs an iron-pot (*w*, *w*,) eleven inches broad, and about nine inches deep, which muſt be encompaſſed with an iron ring (*x*, *x*,) one inch broad, and faſtened at the diſtance of one inch and a half from the upper end of the pot. Let a ſegment (*y*) be likewiſe cut off the upper edge of this pot, which ſegment muſt be four inches and a half deep, and five inches broad: the iron-ring juſt deſcribed muſt be bent all round the edges of this ſegment. 12. Over-againſt the aperture (*t*, *t*,) which communicates from the firſt cavity (No. 7.) into the ſecond (No. 10.), let another ſuch aperture (*z*) be made, two inches diſtant from the bottom of the ſecond cavity (No. 10.) perfectly like the foregoing (*g*, *g*, *t*, *t*,) and communicating obliquely upwards with a third cavity (1, 1, 1, 1,), like and equal to the ſecond cylindrical cavity (*u*, *u*, *u*, *u*,); that the fire may paſs from the latter into the former. 13. In the hinder part of the wall which makes the aperture juſt mentioned (*z*), let a chimney like the foregoing (*q*, *q*, *q*, *q*,), and of the ſame height (2, 2, 2, 2,), be erected, which may be ſhut with a ſlider like that (3). 14. Finally, on the left ſide of the third cavity let an aperture be made in the ſame manner (4), and like the foregoing ones (*g g t t z*); more remote however from the bottom of the cavity, without a paſſage at the other extremity, and communicating only with the cavity of the third chimney (5, 5, 5,), which muſt be erected in the ſame manner as the two foregoing ones (*q*, *q*, *q*, *q*. 2, 2, 2, 2,). Thus you will have a furnace very proper for a great many operations.

" We are now to ſpeak of the uſe of the *athanor* juſt deſcribed; and chiefly to mention, to what operations each of its parts ſerve in particular, and then how the fire may and muſt be governed in it. 1. You muſt put at the upper arched door (*e*) of the tower, a ſemi-cylindrical muffle twelve inches long, which muſt be introduced through the door: which for this reaſon muſt be of the ſame height and breadth as that door, three quarters of an inch thick, and open behind, being ſhut there by the hinder part of the athanor, as far as which it muſt reach. For this purpoſe, a *tile* muſt be ſet upon the grate (*d*) to ſupport the muffle. Let alſo this muffle have ſmall pieces cut out near its baſis, as common aſſay-muffles. You may put under this muffle your cement pots, or ſuch bodies as muſt be calcined with a long and violent fire; which can be done without a muffle, though not ſo neatly. 2. In the firſt chamber (*b*, *b*, *b*, *b*, *i*, *i*,) you may make the moſt violent diſtillations with an open fire: for retorts or large veſſels are introduced into it, after you have taken away the door (*k*, *k*, *k*,) and are put either upon the hearth itſelf of this chamber, or upon a particular ſupport of ſtone. But you muſt place theſe veſſels in ſuch manner, that their necks may eaſily paſs through the hole of the door, when put

put on again: for which purpose, they chuse a support sometimes higher, sometimes lower, according to the different heights of the vessels. When afterwards the door is put on again, and fastened with both its bolts (*n*, *n*,), you must close with lute all the chinks which lie open about the neck of the vessel, and between the edges of the door and the entrance of the chamber. Then you apply to the neck of the vessel a cylindrical segment, ten or more inches long: by means of which the heat and the boiling vapors coming forth are gradually diminished; lest the recipient, which is always chosen a glass vessel, should split. The recipient, which must be united with the other orifice of the said segment, is supported either by the pavement, or by a certain kind of trivet, the construction of which is such, that it may be set lower or higher by means of three screws. 3. In this same chamber, instead of distillations, you may also make cementations, calcination, &c. in which case the round hole of the iron-plate may be shut and again opened with a stopple, that one may view the inside. 4. The second and third cavities (*u*, *u*, *u*, *u*. 1, 1, 1, 1,) serve chiefly to such operations as are made in baths [or beds] of *sand*, *ashes*, or *filings*. For instance, you put into each of these cavities a pot, (*v*, *v*,) and you stop with thin *lute* or with *sand*, which must previously be moistened, the slit between the iron-ring (*x*, *x*,) and the border of the cavity, upon which this ring rests. 5. Besides, you may also make in these two cavities, distillations by a reverberating fire, as well as in the first: only the fire is less violent in these, though sufficient to extract aqua fortis. You then take out the iron-pot (*v*, *v*,) and inverting it, you put it upon the mouth of the chamber; so that the brim of the pot, being the depth of one inch and a half above the iron-ring (*x*, *x*,) wherewith this pot is surrounded, may be received within the mouth of the cavity, and so that the segment cut in the pot (*y*) may, together with the segment cut out from the side of the cavity (*v*, *v*,) form a hole to let the neck of the vessel through. 6. All the *apparatus* being thus ready, you first introduce through the top of the tower (*b*, *b*, *b*, *b*,) a few burning coals; and put upon them some of the unkindled fuel of the fire; that the cavity of the tower may, according as it is thought necessary, be filled either entirely or only in part. Then with all speed you put upon it the iron-cover (*f*), and strew the border of this on the outside with *sand*, or *ashes*, which you press gently with your hands: for if you should neglect this point, all the fuel contained in the tower would be kindled, and may endanger setting the house on fire.

We shall here annex a few general rules concerning the regimen of the fire in this furnace: for it is hardly necessary to explain all particulars, since practice will easily hint them to such as shall be ever so little acquainted with Chemistry. The fire may be made very strong, in the first chamber, (*b*,*b*,*b*,*b*,*i*,*i*,) when the door of the ash-hole (*c*), and the funnel (*q*, *q*, *q*, *q*,) of the chamber is quite open, and when the iron-slider suspended with chains (6. *p*, *p*,) does not hinder the fire from passing freely from the tower into this cavity. But the closer the funnel is shut, together with the door of the ash-hole, the more the violence of the heat diminishes: and this will be soon effected, if the iron-slider suspended with chains is let down in part: for the fuel contained in the tower burns at least as high as the space between the lower edge of the iron-slider and the grate (*d*). Observe besides, in those operations wherein the

round hole of the door is ſtopt with a plug, that when the ſtrongeſt fire is required, this hole muſt not be kept long open; becauſe the air ruſhing violently through it, ſoon cools the bodies put into the cavity. The operations above-mentioned may be performed in the ſecond and third chamber, in, and at the ſame time, and with the ſame fire, as they are in the firſt chamber; for the fire penetrates from the firſt cavity into the ſecond, and increaſes when the funnel (2, 2, 2, 2,) erected on it is opened: but before you do this, the funnel of the firſt cavity muſt be ſhut as much as that of the ſecond is opened. By the ſame means, you may hinder the fire, which ſerves for the operations made in the two firſt cavities, from going out through the funnels, and you force it out, on the contrary, through the third cavity and through its funnel (5, 5, 5,); that it may alſo act upon the bodies placed in that cavity. For the more the funnel erected upon the third cavity is open, the more one or even both funnels of the other two cavities muſt be cloſed: thence it is plain, that you cannot kindle the ſtrongeſt fire in the third cavity, unleſs there be one equally ſtrong in the other two; and that, on the contrary, the heat in the third cavity may be rendered leſs, by cloſing its funnel; though it be violent in the others. The ſame is true of the ſecond cavity, with regard to the firſt. Finally, you cannot make the ſtrongeſt fire under the muffle placed within the upper door *(e)* of the tower, unleſs you have an equal fire in the firſt cavity, which fire may conſequently be increaſed, by ſhutting the door quite againſt the muffle (*e*), and diminiſhed by opening it; there being mean while an equal heat in the firſt chamber, and in the following ones. The reſt will eaſily be learned by practice."

FIG. 3. A REVERBERATING FURNACE.

a, The aſh-hole door.
b, The fire place door.
c, *c*, *c*, *c*, Regiſters.
d, The dome or reverberatory.
e, The conical funnel.
f, The retort in the furnace.
g, The receiver.
h, *h*, Iron bars to ſuſtain the retort.

FIG. 4, 5, 6, 7, *and* 8, repreſent a MELTING FURNACE. Theſe figures and the following deſcription of this furnace are copied from *Cramer's Art of Aſſaying Metals*.

"The melting furnace is made of iron-plates, the inner ſurfaces of which are covered with lute. The cavity of it may be formed according to an elliptical mould. 1ſt. Make an hollow ellipſis, the focus's 12 inches aſunder, and the ordinate 5 inches long; cut it off in both its focus's, that it may aſſume the figure. (*Fig*. 4,). 2dly, Then make in this hollow body, and near its lower aperture, four holes, eight lines in diameter, and directly oppoſite (*c*, *c*,). 3dly, Then faſten two flat iron-rings *(d)*, almoſt one inch and a half broad, at both the upper and the lower inward edge of this oval cavity; and fill the inſide of it with ſmall iron-hooks, jutting out about ſix lines, and three or four inches diſtant from each other. Theſe, together with the rings juſt mentioned, ſerve to faſten the lute. Thus will the body of the furnace be made: only you muſt

add

add at the outside two iron-handles *(e, e,)* to be rivetted on each side of it, that it may be taken hold of and moved. 4thly, Then make the cover of the furnace, which may be formed like the part cut off from the ellipsis (See *Fig*. 5,). Let this have an opening *(b)* made in it, four inches high, five inches broad at bottom, and four inches at the top; and adapt to this an iron door hung on hinges to shut it close, and having at the inside a border fastened to it, answering exactly to the circumference of the door, and as prominent inwardly as the thickness of the lute to be applied to it requires: for the same purpose, let small iron-hooks be fastened to the inside of the door, which is intercepted by the said border. And lest this cover should be burnt within by the force of fire, you must cover the inside of it over with the same lute mentioned before for the assay-oven: therefore it must be likewise furnished with a ring and iron-hooks to fasten the lute; as was said before, when we spoke of the body of this furnace. Besides this, you must fasten two iron-handles *(Fig. 5, c, c,)* on the outside of this cover. Then a round hole must be made in the top of it, being three inches in diameter, prolonged into a hollow tube *(d)* almost cylindrical, and a few inches high, upon which the iron-funnel described may, in case of necessity, be put after the manner mentioned in the same place where we spoke of the assay-oven. 5thly, After this, the lining of both the body and cover of the furnace within is made in the same manner above-described. Moreover, you must make for this furnace two moveable bottoms, *viz.* one to receive the ashes, and admit the air; the other to serve for reductions. The first is made with an iron-plate, formed into a hollow cylinder, open at top, and to be shut at bottom with an orbicular iron-plate, as with a basis, five inches high, and of such a diameter, as that it may receive the inferior orifice of the body of the furnace *(Fig. 4,)* the depth of half an inch *(See Fig. 6.)*: therefore let an iron-ring *(c)* half an inch broad, be fastened on the inside of the said bottom, and at the distance of half an inch from its upper border, to support the body of the furnace put into it. Again, let this bottom have a square door, four inches high, and as many inches broad, that may be shut closely with a door hung on hinges, that you may by means of it increase or diminish the draught of the air, and thus govern the fire at pleasure. Then, on the left side of this door, and at about half the height of this bottom part, let a round hole *(d)* be made, one inch and a half in diameter, to admit the pipe of the bellows when need requires. Next to this, let another bottom part be made of the same matter and figure as the foregoing: let it be likewise of the same diameter, but two inches higher, so that it may be of the height of seven inches. Likewise let it have round it a like iron-ring below its upper border, to support the body of the furnace to be received in it. But let a hole two or three inches broad, and one inch high (*Fig*. 7. *c*.), be cut out just below the ring in the side of this bottom part; then let another round hole be made in the left side of this first hole, fit to admit the pipe of the bellows *(d)*. Further, let another round hole like the foregoing *(e)* be made on the right, and at the distance of one inch from the bottom: then let the whole inside of this bottom-part (the part above the ring excepted) be overlaid with lute, and a bed be made at the bottom, of a figure like that represented by the line *(f, g, h,)*. The matter of which this is made

is common lute pulverised, passed through a sieve, and mixed with such a quantity of dust of charcoal, sifted in the same manner, so that the mixture being moistened and pressed down, may at least be lightly coherent. Of this matter pressed on the bottom of the bottom-part a bed is made, like a segment of a sphere, having in the middle a small cavity somewhat lower, and made extremely smooth, after the manner mentioned before when we spoke of large ash-vessels or tests.

This furnace is chiefly fit for fusions, which may be made in it with and without vessels. When you are to melt with a vessel, put the body of the furnace (*Fig.* 4.) upon the first bottom (*Fig.* 6.), that has a door to it to open on hinges; introduce two iron-bars through the holes of the furnace (*Fig.* 4. *c, c*); put upon them the iron-grate, which you are to introduce through the upper mouth of the furnace: then put in the middle of this grate a *brick* or square *tile*, very smooth every where, warmed, and perfectly dry: otherwise, the vessels put upon it, especially the large ones, are easily split by the moist vapors coming out of it in the operations. Let the height and width of this *stone* be a small matter broader and higher than the bottom of the crucible or pot to be set upon it; for if it were less high, the bottom of the vessel could not be sufficiently warmed; and if it were less broad, the vessel might easily fall from it: then put upon this *tile* the vessel containing the matter to be melted, and surround it immediately with coals on every side, which must be ranged according to the method prescribed before, in our description of the assay-furnace: then you govern the fire, by opening and shutting the door of the ash-hole (*Fig.* 6. *b*): you excite it by putting the cover (*Fig.* 5.) upon the body of the furnace; and if, besides, you put a funnel upon the cylindrical mouth (*d*) of this cover, the melting fire becomes still more violent: but if you moreover introduce the bellows through the hole of the bottom part (*Fig.* 6. *d*); and the joint of the furnace with the bottom part, and the door of the ash-hole, unless it can be shut very close, being exactly stopt with thin lute [*or Windsor loam*], the fire thus excited by the blast of the bellows is carried to the highest degree, and far surpasses that which may be made in a Smith's forge. Another advantage of this method is, that the vessels are not so easily broken, because the blowing of the bellows cannot affect them immediately, and because a fire perfectly equal is excited on every side. One may easily examine with this *apparatus*, how *stones* are affected by the violence of the fire only. Now, if you have a mind to perform any operation without a vessel, and with a naked fire; for instance, to melt and reduce the *calxes* or *scorias of copper*, *tin*, *lead*, and *iron*, or the ores of these metals; the body of the furnace must be put upon the other pedestal, having a bed in it (*Fig.* 7.). However, you must, before this, open with a knife the oblong hole (*c*), and the round one (*d*) of this bottom part, which are stopped with the lute sticking to the inside: then you apply at the round hole (*d*) on the left side of the bellows, in such manner that the nozzle of it, being directed obliquely downwards, may blow strongly against the bed (*f, g, b*): by this means, all the ashes that fall into the bed are blown away, and the strength of the fire determined to such a degree, that all the melted bodies that fall into the said bed remain in their state of fusion; and were it otherwise, the melted bodies would immediately wax cold, and

adhere

adhere in grains to the bed, *whereas they ought to have melted into one regulus*. The oblong hole in the fore-part of this bottom-part (*c*) ſerves to diſcover, by means of a poker, whether the matter in the bed be melted or not: it ſerves likewiſe to take away through it whatever might ſtop the bellows, and in ſome caſes to take away the *ſcoria*: then you put firſt coals into the furnace one ſpan high, and blow them well with the bellows, to make them burn, that the bed may be very hot before the matter to be melted is put into it; for if this is not previouſly done, the melted maſs ſeldom runs into a *regulus*, but remains diſperſed among the *ſcorias*, which ſoon grow hard. The bed being well heated, and freſh coals added to the fire, put into it ſuch quantity of the matter to be melted as cannot hinder the fire from being carried to the requiſite degree; which cannot be determined otherwiſe than by experience: again, put freſh coals, and upon them another quantity of the matter to be melted; they may be, like *ſtrata*, one upon another: but if the maſs, once melted, could not long ſuſtain the ſtrength of the fire, or if you had a mind to melt a greater quantity of matter than what can be contained in the bed, you muſt open the round lower hole (*Fig*. 7. *e*), that you may make a channel paſſing from that hole through the lute, and reaching to the ſmall cavity at the bottom of the bed (*g*): to this hole, at the outſide, apply an earthen diſh like the bed within, or any other proper recipient, ſurrounded with burning coals, into which the matter melted, running from the bed through the hole (*Fig* 7. *e*.), may be collected, as is repreſented by *Fig*. 8.

Fig. 9. A tranſverſe ſection of a Furnace in which Sulphur is obtained *by diſtillation* from pyrites. In this furnace are placed ten or twelve tubes, one of which is repreſented in this ſection (7), lying acroſs the whole breadth of the furnace. Theſe tubes are open at both ends. At the larger end, the mineral, form which the ſulphur is to be diſtilled, is to be introduced; and then the opening is to be cloſed with an earthen ſtopper. The ſmaller end opens into a caſt-iron receiver (8), which receives the ſulphur that is diſtilled or eliquated. To prevent the crude mineral from paſſing into the receiver, a ſtar-like piece of baked earth is placed in the neck or ſmaller end of the tube, along with the ſulphur. Each furnace contains ten or twelve ſuch tubes. The length of the whole furnace is therefore evidently much greater than its breadth. The tubes are about four feet long, ſomewhat of a conical form, ſix or eight inches wide at their larger end, and three quarters of an inch at their ſmaller end.

1. The walls of the long ſides of the furnace.
2. The aſh-hole.
3. The grate made of bricks.
4. The fire-place.
5. The paſſage for the flame to the upper part of the furnace.
6. The two walls of the long ſides of the furnace which ſupport the tubes.
7. A tube placed acroſs the furnace.
8. A ſquare caſt-iron receiver.
9. Two holes in the roof of the furnace through which the ſmoke eſcapes. There are generally ten or twelve ſuch holes in different parts of the roof, ſome of which are occaſionally cloſed. *See a further deſcription of*

this

this furnace, and of the operation of extracting sulphur, at the article SMELTING *of* ORES.

FIG. 10. This figure represents a transverse section of a FURNACE *for* PURIFYING SULPHUR *by* DISTILLATION. *See* SMELTING *of* ORES.

1. The foundation of the wall sunk under ground.
2. The side-wall.
3. The back-wall.
4. The ash-hole.
5. The grate.
6. The fire-place.
7. Two holes through which the smoke escapes.
8. The inner chamber of the furnace.
9. An iron cucurbit or pot.
10. A neck made of earthen-ware.
11. The vessel called the fore-runner.
12. A receiver.
13. A banquette or step raised to support the fore-runner. In this furnace, which is of an oblong shape, generally five or six such setts of distilling vessels are placed on each side.

FIG. 11. Represents a *quantity of ore piled up to be roasted.*

1. Two sides or faces of the pile. All the sides of it are covered with small ore.
2. The upper part of the pile, where holes or cavities are seen in which the sulphur of the ore is collected.
3. An opening where part of the pile has fallen down, and in which the sulphur is seen dropping down.
4. A plank to keep off the wind. *See* SMELTING *of* ORES.

FIG. 12. *A Section of the above Pile.*

1. The wood to make the fire.
2. Some charcoal for the kindling of the fire.
3. A channel formed by a wooden tube or pipe.
4. The large lumps of ore.
5. Small ore.
6. Finer ore, or dust of ore.
7. The substance called *vitriol,* that is, a half roasted ore powdered.

FIG. 13. Represents a longitudinal section of the FURNACE *at* RAMMELSBERG. *See a description of this furnace at the article* SMELTING *of* ORES *of* SILVER.

1. Foundation of the masonry in the ground.
2. A part of the back wall.
3. The tuyere.
4. Channels to carry off moisture.
5. The covering stone of these channels.
6. A bed of scoria.
7. The case or casse made o bricks.
8. A bed of clay.
9. A bed of sifted ore and substance called vitriol.
10. The charcoal which is thrown into the casse previous to the filling of the furnace with ore and fuel.

11. A